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OBSCURATION OF THE MARTIAN SYRTIS MAJOR.

By E. C. SLIPHER.

PLATE IV.

THE PHOTOGRAPHS WERE MADE THROUGH THE 24-INCH REFRACTOR AND AN ORANGE COLOR FILTER ON CRAMER ISOCHROMATIC PLATES WHICH TENDED TO REDUCE THE PHOTOGRAPHIC BRIGHTNESS OF THE WHITE PATCHES TO THAT OF THE ORANGE BACKGROUND OF MARS.

DUE ALLOWANCE MUST BE MADE FOR THE LOSS OF DETAIL IN THE DIRECT PHOTOGRAPHS ENTAILED IN THE PROCESSES OF REPRODUCTION. IT IS HOPED THAT THE REPRODUCTIONS OF THEM WILL CONFIRM, IN A GENERAL WAY, THE ASPECTS OF THE PHENOMENON DEPICTED IN THE DRAWINGS.

TO AID IN COMPARISON SOME DRAWINGS HAVE BEEN REDUCED IN SIZE AND PLACED WITH THE PHOTOGRAPHS.

DRAWINGS AND PHOTOGRAPHS BY E. C. SLIPHER, LOWELL OBSERVATORY.

An outstanding feature of the observations of Mars at the 1920 apparition was the unusual, extensive and conspicuous cloud-like forms seen over its surface. Although this is not an entirely new phenomenon on the planet yet the areas affected, this year, were particularly large and distinct. As the most marked effect of these bright areas centered about the Syrtis Major, longitude 285 degrees, my remarks will be confined mainly to the appearance of that region.

Circumstances concerning the planet were:

Vernal Equinox, N. hemisphere	1919, July 24
Aphelion of Mars	1919, December 17
Summer Solstice, N. hemisphere	1920, February 8
Opposition of Mars	1920, April 20
Autumnal Equinox, N. hemisphere	1920, August 7

The planetocentric declination of the Earth, referred to the planet's equator, decreased from 18°.8 on January 29, when the observations began, to 15°.9 on March 13, increasing again to 23°.1 on June 11, after which it decreased—very rapidly towards the end to 4°.7 on October 1. The diameter of the planet at its maximum was 16″.05 and ranged from this down to about 11″ during the period of time covered by the observations that will be referred to here.

From the foregoing circumstances concerning the planet it is apparent that the northern hemisphere was extremely well presented for observation, the Earth being twenty degrees north of the Martian

equator for the most part and with mid-summer occurring there then. the northern polar cap had receded to almost its minimum extent by opposition date, exposing practically all of that hemisphere to view.

During the early part of the observations of this year the major regions of the planet appeared normal in outline and tone, as seen through the 24-inch refractor, but in the latter days of February the conviction forced itself upon me that the finer details were particularly hazy and diffuse. This recalled a similar aspect of the planet presented during the early part of the opposition of 1909 although at that time the southern hemisphere of the planet was turned towards the Earth. However I was not prepared for the appearance, a few days later, in March, of a misty, bluish-white covering thinly veiling the Syrtis Major, dimming its outlines and making it paler, as that region was seen passing off the sunset margin of the disk. A careful and systematic scrutiny of this region was begun, when, in April, it was again presented for view. On April 11 it exhibited a peculiarity of structure and faintness that was immediately evident, and which quite astonished me, being so different from the usual Syrtis. This marking, usually the most conspicuous object on Mars, had become extremely feeble in parts as if covered with some highly reflective medium, which, although not sufficiently dense to entirely obliterate the marking, had tinted it a much lighter tone or partially concealed it.

This condition prevailed, to a greater or less degree, until the end of May. During this period various unusual aspects of the Syrtis were produced by this obstructing medium. Some of these appearances are portrayed in the drawings and photographs accompanying this article. Unfortunately only a few of the many interesting photographic and visual observations of this rare phenomenon can be reproduced here.

In the photographs and drawings of April 12 (Plate IV), the Syrtis Major region is shown near the sunset margin of the disk, almost completely hidden underneath a brighter covering which is seen to extend well over into the Aeria region. Notice, also, the bright mass along the right-hand side of the planet and north of the equator.

From the observations made on April 23 note that the Syrtis Major, when near the sunrise (right-hand) edge of the planet, is again almost entirely concealed beneath an obvious, bright area which left exposed only the northernmost tip of the marking; but on the photographs made at Martian noon of the same day, the Syrtis shows clear and normally dark.

Compare the last group of photographs above with the extraordinary aspect of the object as recorded in the photographs and drawings of May 25 and 26, when, again the region appeared well toward the center of the disk and only the northern part of the Syrtis stood revealed, looking somewhat like an island. This shrouded condition of it existed, apparently unchanged, for about four days.

In Plate V the drawings of April 12 and 13 show the Syrtis divided

into zones by the banded structure of this white mask. These bands of which the object appeared to consist were almost completely disjoined but for two or three canals that seemingly were intense enough to show through the hazy veil like so many dark rifts. This zoned appearance was not seen when the region was observed again on May 16. On May 22 the Libya was remarked as being very bright; also the preceeding side of the Syrtis was concealed, and the remaining, narrow portion of it, too, was distinctly paler than common. Thus the object looked unnaturally long and narrow (Plate V). This new aspect continued to be visible while the region was observable in the light of the Martian evening.

Perhaps the most important change in the Syrtis Major was that observed on May 24 when that region was seen again at the central meridian for the first time since the presentation of it in April. It was at once obvious that the southern part of the Syrtis was distinctly paler than it had ever appeared before at Martian midday. Although the whitish canopy that hung over the region was not especially conspicuous at the central meridan, it soon became so a little distance away. The concealment of the Syrtis Major, at the south, was striking on May 24, 25, 26, and 27, even when virtually in the middle of the disk. Both the visual and photographic observations made on these dates showed it to be almost completely separated from the main dark region to the south by a dull white area several degrees wide. Only two or three canals, common to this region, faintly showed through to bridge the gap. The isolated northern end of the Syrtis Major was seemingly unaffected and stood out normally dark.

On May 28 and 29 observation showed the Syrtis Major emerging from its misty shroud but still pale. Seemingly only a few days elapsed until it was practically normal again. The exact time of its return to normal is somewhat in doubt because this longitude soon passed off the visible disk. However when this region again came into view in June not a semblance remained of the misty-white phenomenon that had masked this region, in a varying degree, for more than two months. Numerous photographs of the planet record these remarkable appearances and changes. Inferentially the maximum density and extent of this cloud-like veil appear to have occurred about May 24 to 26. At that time it extended over a vast area covering Libya and a considerable portion of Aeria, thus reaching from about longitude 255 degrees to approximately 312 degrees and in latitude from about 9 S. to 11 N., or spreading over an area 20 degrees wide and 60 degrees long.

The color tone of this obscuring medium was a dull, bluish white over the light regions but merged into a more or less dull greenish white over the dark markings, as if these faintly showed through to produce a blended white. It did not show the yellow tint that has been assigned to the dust clouds of Mars. Nor did it possess the glis-

tening brillancy of the polar caps. However the brightness was sufficient to make it appear fairly conspicuous when near the margins of the disk, but it usually faded to invisibility, except at its maximum, as it approached the center of the disk. Thus it seems to have been a morning and evening phenomenon, rather than a noonday affair on Mars. Whether it was a recurrent morning and evening haze, or merely too thin to be seen at noonday on the planet but obvious under the more oblique vision and illumination of the forenoon and afternoon, is a matter of doubt. It seems that both things contributed their share to its appearance.

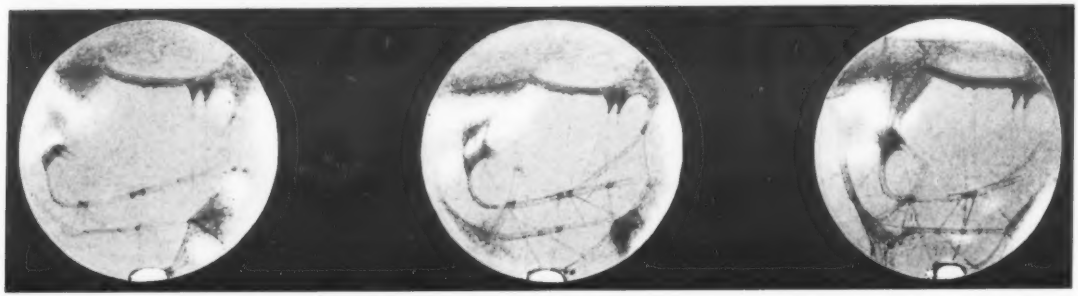
The unusually strong limb-light present in the northern hemisphere was significant, as was the fact that these bright areas matched it so perfectly in tone and merged into it so evenly at the margins of the disk. This condition is portrayed in the drawings and photographs of April 12; note especially the right side of the disk where this equatorial cloud is to be seen harmoniously coalesced with the visible limb-light. It is also noteworthy that when the planet was viewed through a blue filter these bright areas stood out very prominently.

An analysis of the observations showed that telescopic definition did not modify the appearance of the Syrtis Major, as other and much finer details were always visible. The same inquiry proved the absence of inherent changes in the markings, themselves, that would account for any phase of the phenomenon. Thus the facts force the inevitable conclusion that a tenuous obscuring medium overspread the region.

What substance produced this effect? is a question which naturally presents itself for answer. The polar caps are the only features on Mars which possess the power to conceal the surface, but this misty canopy was found by easy comparison to differ from them in every essential respect. Furthermore the cap in the northern hemisphere where this phenomenon occurred was at the time melting, therefore it is certain that, at the same time, their like could not have formed and persisted in the greater heat at the Martian equator. Then the obvious and logical inference is that this veiling of the Syrtis Major was due to material, cloudlike in appearance and behavior, suspended in the Martian atmosphere. Moreover, from a free and unbiased consideration of the foregoing facts and of our knowledge of matter, mundane as well as Martian, leaves us with the only alternative we know of: vapor of water.

While examining the recorded observations of this phenomenon another interesting and wholly unexpected fact emerged from them regarding the actual existence of the canals on Mars, which seems worthy of mention here although, perhaps, few if any regular observers of the planet seriously question their reality. To account for the canals it was suggested by Mr. Green, and later advanced by M. E. M. Antoniadi and subscribed to by some others, that they were merely con-

PLATE V



April 12
λ=335°

April 13
λ=328°

May 22
λ=318°

MARS 1920.

Drawings by E. C. Slipher.

trast effects seen between areas of different brightness or gradations of tone. Then, in this phenomenon discussed here, nature provided an ideal experiment covering this question, with both these conditions of brightness and tone visibly present. Although the general form of this whitish area was roughly traceable, due to its brightness and tone, however, no dark border or new lines were seen anywhere about it, which indisputably proves the fallacy of the theory. The photographic observations are equally decisive in the disproof of it.

Again referring to the main subject I wish to point out that similar cloud-like areas have been observed on Mars in the past. Dr. Lowell recorded similar appearances of the Syrtis Major in 1903 and 1905. Mr. W. F. Denning observed a like obscuration of the same marking, when at the central meridian, on May 21, 1903, *(Monthly Notices,* June, 1903). Rev. T. E. R.Phillips calls attention to the same aspect in 1903, *(Monthly Notices,* Nov., 1903*)*. Similar phenomena have been observed by the writer, over other regions of the planet, not only this year but also in 1907, 1909, 1911, and 1918, but none, perhaps were as persistent or as remarkable in effect as the one described here.

Generally, it seems that these cloud-like areas have appeared, or have been most prominent at the time of the greatest melting of the polar cap in the summer hemisphere. It is a significant and notable fact that the disappearance of this mist-like covering, this year, was coincident with the appearance of what seemed to be cloud and frost about the north polar regions of the planet. Thus it seems probable that a more complete examination and study of the appearance and behavior of such markings will positively show them to be of atmospheric character, and result in establishing a close relationship between them and the polar caps. This, doubtless, would finally disclose the unquestioned identity of both, and permit us to deduce much other valuable information concerning the planet. A more comprehensive investigation of this and other like phenomena that have been observed on Mars will appear later.

CHANGES IN THE MARTIAN SYRTIS MAJOR OPPOSITION OF 1920.

By G. H. HAMILTON.

The Syrtis as I drew it for the first time this year, on March 8, was unrecognizable; if it had not been for my knowledge of the region that should have been on at that time and for other familiar detail I would have unhesitatingly considered it an entirely new marking, or that of some other planet. My two drawings on that night are remarkably in accord, but in spite of this and the fact that Mr. O. H.

Truman's description of his impressions of the region at that time corresponded with my drawings, I was unable to reconcile the observations with what I thought I should have seen. Unfortunately owing to weather conditions I had only one other opportunity to view this region to advantage before the next presentation. This phenomenon was, of course, astonishing to me and I tried to make my drawings portray as nearly as possible what I saw. Later, from a further study of the region about the Syrtis, I found my drawings on the night in question might well have shown the detail as it appeared.

From these first observations I was led to expect, and with reason as was proved throughout the opposition, that there would be other interesting ones later on; and I eagerly awaited the returning presentations of this remarkable region.

The Syrtis seemed normal up to March 8, from then on it appeared long and slender especially near the limb or terminator where the angle of view would add to, but not wholly account for, the effect. Two different causes probably contributed their individual share to this effect. Primarily the southeastern edge of the Syrtis seemed to have almost completely faded out and taken on the appearance of the adjacent desert. In the second place there had been a systematic obliteration of both the eastern and western edges by what one cannot help but feel was cloud. It is this phenomenon in connection with the Syrtis which forms the subject matter of this article.

My observations of the Syrtis were obtained on twenty-five nights and many drawings were made. I will only describe, however, the few which will accompany this article.

The drawing of March 8, Fig. 1, (Plate VI) shows the Syrtis covered in part: the southern portion has the appearance of a broad triangle while the "Tip" is indistinguishable down to the Pseboas Lucus. That of April 13, Fig. 2, is of interest and I intend to mention it further on. On May 16, Fig. 3, my drawing shows much haze, apparent only through its diffusing effect on the markings of the disk, and what is seemingly cloud in different localities, while that of May 19, Fig. 4, with the Syrtis uncovered, shows it cut off on the east by cloud. This is also shown in photographs taken by Mr. E. C. Slipher.

The planet is also shown as it appeared on April 28, Fig. 5, with the Syrtis coming onto the disk; the tip only visible from under a blue-white haze of the appearance of cloud, while the Triton and canals paralleling it are broad and intense. The two drawings, one of April 23, Fig. 6, the other of May 24, Fig. 7, shown side by side are remarkable for their difference. In that of April 23, the Syrtis seems completely free from cloud, while on May 24, the whole southern region is obscured. This region cleared to a certain extent later that day, as is shown by the last drawing, Fig. 8.

Though the cloud formations may have been no more brilliant than the surrounding desert, their color, a blue-white, showed distinctly by

contrast to the rose-ochre of the desert. The pencil drawings were incapable of portraying this color difference, therefore the cloud appears, perhaps, too definite in the reproduction, since to show it, it has been necessary to lighten the cloud areas with respect to the desert.

Photographs taken in yellow-green light with color screen show the clouds very well; as do also, to a greater extent those taken with blue film and correcting lens. These photographs will be dealt with more fully by the observers who took them.

Cloud formations have been observed over the Syrtis at other oppositions—notably by Dr. Lowell, in 1903, 1905 and 1909. A rather interesting observation, which was seemingly of a similar nature, was made by Lockyer in 1862, October 3.

One of the most interesting drawings of the covered Syrtis was made on April 13, $12^h\ 11^m$ M.M.T., $\lambda=344°$*. It shows an accentuated appearance corroborated by a drawing made by Mr. E. C. Slipher. Dr. V. M. Slipher who chanced to observe the planet that evening described the same feature. There was a dull white to the east and west of the Syrtis, and covering it in part. It divided the Syrtis into three distinct areas; these areas were connected by what were presumably rifts in the overlying haze. These rifts may indeed have been canals in the Syrtis itself, darker than their surroundings, and therefore showing through the haze. This white at this time, and also on other occasions, did not seem a surface marking, but hung over the disk at the terminator as an almost constant area while the Syrtis seemed to slip under it as the planet rotated. I have some seventeen drawings of nearly this longitude ($\lambda=344$), showing the variations of this apparent cloud formation at different times during the opposition. This covering varied in intensity and form not only as the season changed on Mars but during different periods in the same day.

In the drawings around longitude 290°, of which I have about twelve, showing the Syrtis near the center of the disk, there is a preponderating lack of obscuration, the Syrtis showing nearly the whole of its area but yet in varying intensity. In one or two of the drawings, such as those of May 24 and 25, the southern region of the Syrtis remained obscured and markedly so during the time of the drawings when the Syrtis was about 20° from the center of the disk; from this, it seems, the phenomenon was then at its maximum. In these drawings the cloud was probably thinner above the Lucus Moeris than further north, as the color was more of a drab and dingy green intermingled with the predominant blue-white and was due in all likelihood to the dark areas showing through the mist to a certain extent.

In the nine drawings of the Syrtis as it comes onto the disk from the limb before opposition and from the terminator after opposition, its southern region is obscured by this white covering, from under which it appears to come as it approaches the center of the disk.

* λ = Martian Longitude of central meridian at time of drawing.

It has already been remarked that the Syrtis seemed to slip under this covering as it approached the terminator or limb; from these two phenomena we may then conclude that the markings were atmospheric, and the observations and drawings as well, lead me to believe that it is an evening and morning effect on Mars.

Though condensation in the Martian atmosphere to the point where it obscures the surface markings during the morning and evening has been observed to some extent before at this Observatory, notably in 1905 and 1909 as is shown in drawings made by Dr. Lowell, the observations during this opposition seem to show that the clouds have extended unusually far into the day. That is, the clouds do not seem to have dissipated till long after the rising of the sun, and they have formed in the same manner long before the sun has set.

This opposition has, to a great extent, re-opened to our consideration a wide field in the atmospheric study of the planet Mars. Just what a fuller investigation and discussion of these observations will reveal, remains to be seen; but it will probably need the data drawn from many previous as well as future oppositions to give us the key to what we have observed in this.

As it should be of interest, it is intended to make a general investigation of all past observations in order that more light may be thrown upon this phenomenon.

TWENTY-FOURTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

(*Continued from page 32.*)

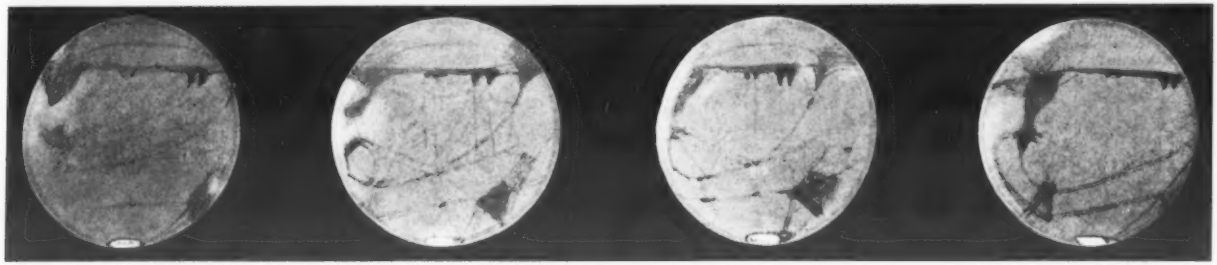
ABSTRACTS OF PAPERS

THE INVESTIGATION OF PLATE ERRORS IN PHOTOGRAPHIC PHOTOMETRY.

By Harlan True Stetson.

From previous reports it will be recalled that the thermo-electric method in photographic photometry has made possible an impersonal determination of magnitudes from the star images on photographic plates with a probable error of measurement of about one one-hundredth of a magnitude. Larger discrepancies than could be accounted

PLATE VI

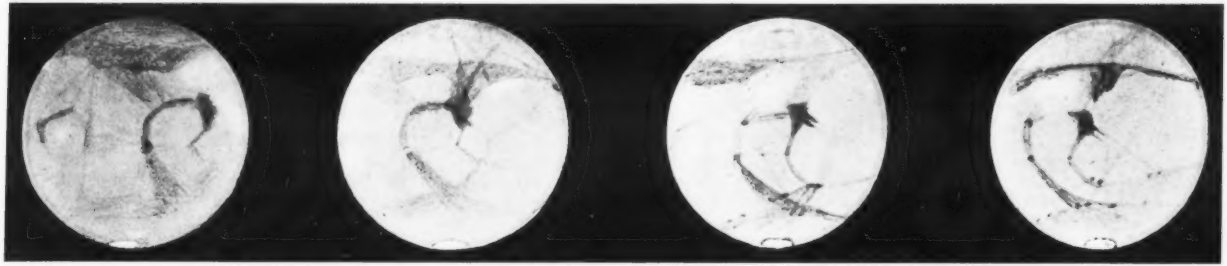


Mar. 8 $\lambda = 335°$
Fig. 1

Apr. 13 $\lambda = 344°$
Fig. 2

May 16 $\lambda = 350°$
Fig. 3

May 19 $\lambda = 326°$
Fig. 4



Apr. 28 $\lambda = 250°$
Fig. 5

Apr. 23 $\lambda = 284°$
Fig. 6

May 24 $\lambda = 277°$
Fig. 7

May 24 $\lambda = 305°$
Fig. 8

DRAWINGS OF MARS BY G. H. HAMILTON

for from the accidental errors of measurement have been thought to be due to irregularities in the plate itself.

Variation in sensitivity of the emulsion over a single plate would be dependent upon the thickness of the film which would vary with the degree of concavity of the ordinary commercial plate, and upon the conditions of manufacture and manipulation, perhaps the first of which to be mentioned is irregularity in drying.

Experiments have been extended since the report at the Cambridge meeting in 1918 resulting in an improved form of apparatus for imposing artificial star images on the plates with a system of diaphragms producing an absolute scale and thus making possible the interpretation of plate errors in terms of magnitude differences. Thus far data have been collected for artificial star images ranging from one to two tenths of a millimeter and indicate for Seed 30 plates on ordinary glass a probable error for a single image (excluding the region near the edge of the plate) of $0^m.05$-$0^m.08$. To minimize the error in the emulsion due to the concavity of the commercial plates, some 4x5 plate-glass plates were specially coated for the purpose through the courtesy of the Eastman Kodak Company with the Seed 30 and the Seed 23 emulsions. The results for these plates however did not show any marked improvement seeming to indicate that the concavity of the ordinary plate is not the chief source of the plate errors. The probable error for a single image for the plate-glass plates tested was about $0^m.05$ in the case of Seed 30 and $0^m.06$ for the Seed 23 emulsion.

Although such errors are considerably larger than were anticipated, it is believed that by improved conditions in drying both in the manufacture and subsequent manipulation, and some further investigation in the choice of developers for photometric purposes, it may be possible to considerably increase the present degree of precision in determining magnitudes photographically. The importance of such needed improvements can hardly be over-emphasized since the photographic plate is by far the most sensitive detector of radiation known to astronomy whereby quantitive results of permanent record may be secured for the fainter stars.

ARLINGTON TIME SIGNALS.

By R. Meldrum Stewart.

Since March 1918 it has been the practice to make a comparison daily between the noon wireless signals sent out by Arlington and the Riefler standard sidereal clock at the Dominion Observatory. The results of these comparisons are given below.

The comparison is effected by the method of coincidences, by the use of a break-circuit chronometer which is rated to gain about 15 minutes

per day on mean time, and is chronographically compared with the sidereal clock a few minutes before and after noon each day. A relay controlled by the chronometer, beating seconds, each beat being one-half second in duration, is so arranged that the aerial receiving circuit passes over its points; wireless signals which arrive during the half-second when the points are closed are therefore audible, those arriving during the complementary half-second inaudible. It follows from the difference in rate that only alternate groups comprising each about fifty consecutive signals are audible, and on account of the finite length of the signals (about ¼ sec.) they appear to be gradually encroached upon and shortened as the coincidence is approached, becoming inaudible at the instant of coincidence; except when the signals are extremely weak the particular chronometer-beat when the signals become inaudible is perfectly definite. The probable error of a comparison from a single coincidence is about ±0.01 sec.; usually it is possible to observe three coincidences during the five minutes for which the signals continue. Comparisons were formerly made without the relay-points inserted in the aerial, by introducing the chronometer signals by induction; the results of the two methods are accordant.

Having performed the comparison and applied the corrections issued by the U. S. Naval observatory, including that for the lag of Arlington, it is a simple matter to compute the resulting correction (according to Arlington) of the sidereal clock. These corrections run with remarkable smoothness from day to day, an evidence of the smoothness of rate of the Riefler clocks employed.

For the purpose of the comparison given below the corrections so obtained (for noon) were interpolated to the time of observation for each night on which observations were obtained at Ottawa, and the differences from the observed corrections tabulated in the sense "Arlington slow." Following are the monthly means and the number of nights upon which each depends.

1918	s		1919	s	
March	0.115	6 nights	January	0.154	5 nights
April	.062	14 nights	February	.067	7 nights
May	.104	14 nights	March	.059	10 nights
June	.075	16 nights	April	.028	5 nights
July	.043	16 nights	May	.088	6 nights
August	.073	14 nights	June	.072	15 nights
September	.133	6 nights	July	.082	10 nights
October	.057	11 nights	August	.069	7 nights
November	.022	6 nights	September	.115	12 nights
December	.020	6 nights	October	.060	5 nights
			November	.120	2 nights
			December	.170	7 nights

Mean by months 0s.081
Weighted mean (200 nights) .077

Of the individual differences fourteen were negative, eighteen were greater than 0s.15, and of these four greater than 0s.20, the extreme values being —0s.07 and +0s.28. There appears to be no room for doubt as to the systematic nature of the difference; the explanation must

apparently lie either in a lag of the Arlington signals or in an error in the assumed difference of longitude between Ottawa and Washington.

Dominion Observatory, Ottawa, August, 1920.

TEMPERATURE COMPENSATION OF CHRONOMETERS.

By R. Meldrum Stewart.

During the winters of 1919 and of 1920 temperature tests were carried out on seven box chronometers belonging to this Observatory, which are used for astronomical and geophysical field work. Of these one is by Roskell, two by Bond, one by Nardin and three by Dent. Exclusive of the Roskell, which is old and has been out of use for some years, it had been concluded from the results of actual performance in the field, as well as from tests at ordinary temperatures, that the Nardin was the best chronometer, and that all three Dents were decidedly poor. How far this conclusion requires to be modified, and why, will be seen below.

The temperature-room, specially built for the purpose, consists of a small space in the basement of the transit-room, partitioned off by double board walls and ceiling lined with shavings. Provision is made for electrical heating, controlled by a thermostat, and for the admission of cold outside air when required. Tests of the chronometers of five or six days duration were made approximately at each of the temperatures 40°, 30°, 20°, 10° and 0°, and were then repeated in the inverse order, occupying ten weeks in all; the extreme range of temperature is little more than that to which they are occasionally subjected in the field.

The (losing) rate of any compensated chronometer, as is well known, shows a minimum at some definite temperature depending on the adjustment, which is known as the temperature of compensation; for ordinary purposes this should be in the neighborhood of 20° C. For temperatures either above or below this the losing rate is increased, and by equal amounts whether above or below; the rate curve is approximately a parabola with axis perpendicular to the temperature-axis; it may be represented by the formula

$$a+b(t-t_1)+c(t-t_1)^2$$

where t is the temperature, c is a constant measuring the curvature of the parabola, and $t_1 - b/2c$ is the temperature of compensation, t_1 being any adopted temperature. The reciprocal of c is therefore a measure of the possible efficiency of the compensation, that is, of the flatness of the rate-curve, while the ratio $b/2c$ is an indication of the nicety of its adjustment.

In the following table are given, for each chronometer, the values deduced from the tests for the constants b and c and for t_0 the temper-

ature of compensation, as well as the extreme range of observed rate corresponding to the temperature of the tests; t_1 was taken as 20°.

	1919				1920			
	b	c	t_0	Range	b	c	t_0	Range
Bond 511	—0^{s}068	0^{s}0113	23°	5^{s}0	—0^{s}029	0^{s}0099	21°	4^{s}3
Bond 627	— .018	.0079	21	3.0	— .022	.0088	21	3.8
Nardin 506	.002	.0026	20	0.9	.014	.0021	17	1.1
Dent 52866	— .141	.0015	66	5.3	— .126	.0022	48	5.1
Dent 48419	.415	.0013	—140	16.3	.044	.0005	—23	1.9
Dent 52865	— .196	.0002	480	7.4	.004	.0022	19	0.9
Roskell	.289	.0164	11	14.2	.070	.0081	16	4.8

From the 1919 test it was evident from a comparison of the values of c that the rate-curves of all three Dent chronometers were at least as flat as that of the Nardin, and much more so than those of the Bonds; their poor performance, shown by the range in the last column, was evidently due to improper adjustment, the result of which appears in the values of t_0. Previous to the 1920 test an adjustment of the temperature of compensation was attempted in the case of Dent 48419, Dent 52865 and Roskell. As will be seen from the 1920 section of the table, the alteration was apparently not carried far enough in the case of Dent 48419, though the extreme flatness of its curve makes this of comparatively little moment; the diminution in the range of rate is very marked for all three chronometers. The improvement in the rate curves is striking when exhibited graphically as in the lantern slides; the performance of Dent 52866 can evidently be materially improved by a similar adjustment.

The purpose of this paper is to draw attention to the importance of the adjustment of the temperature of compensation, and to the ease with which it may be effected by anyone reasonably familiar with mechanism of this order of delicacy. The adjustment should, to be sure, have been made by the makers; and it is curious that a compensation of such a high order as that of these Dents should have been left in such a poor state of adjustment.

The process of adjusment, as stated above, is extremely simple; it consists merely of moving the compensating weights along the rim of the balance wheel in the proper direction, care being of course taken that the opposite weights remain symmetrically placed. Two or three trials, alternating with rate-tests for one day at each of the extreme temperatures, were in each case sufficient to obtain the results described above, which have transformed several of our poorest chronometers into several of our best.

CANADIAN TRANSCONTINENTAL LONGITUDES.

By R. Meldrum Stewart.

In the course of Canadian longitude operations three independent transcontinental determinations have been made, two of them connect-

ing Ottawa with Vancouver, and the third Ottawa with Seattle. As Ottawa has been connected with Montreal and Harvard, and Vancouver with Seattle, each of these affords a connection between Montreal and Harvard in the east, and Seattle in the west. As the latter three stations are involved in the longitude net of the United States, of which an adjustment was made by C. A. Schott in 1897, the comparison is of interest.

The three resulting longitude differences, Seattle (station of 1886)-Montreal, with the routes and the initial and final dates, are as follows:

1. 1885-1896. Via Ottawa (Cliff Street Observatory), Winnipeg and Kamloops (four links)

$3^h15^m1^s.609$

2. 1896-1905. Via Ottawa (Cliff Street Observatory) and Vancouver (three links)

$3^h15^m1^s.637.$

3. 1896-1911. Via Ottawa (Cliff Street Observatory), Dominion Observatory, Winnipeg (new observatory), Field and Vancouver (six links)

$3^h\ 15^m\ 1^s.613.$

Of the individual links, that connecting Montreal with Cliff Street Observatory, which is common to all three routes, was well determined, consisting of ten nights observations with exchange of observers after the fourth night; the interagreement of individual nights was above the average. The link Vancouver-Seattle, common to two routes, may from outside evidence also be considered good; it formed a part of a closed loop consisting of six links observed internationally to determine the 141st meridian, the boundary between Yukon and Alaska, the closing error of the loop being only $0^s.003$. Two of the links involved in the first route were, however, weak.

The mean of the three above results, $3^h15^m1^s.620$, is less than Schott's adjusted difference, $3^h15^m1^s.724$, by $0^s.104$.

Substituting Harvard for Montreal as the eastern terminus, the mean of the three differences, Seattle-Harvard, is $3^h24^m49^s.119$, which is $0^s.193$ less than Schott's adjusted difference of $3^h\ 24^m\ 49^s.312$. The link Ottawa-Harvard, is weak owing to an uncertainty in the personal equation, which, however, could scarcely amount to a tenth of a second.

There is thus an unexplained difference of at least a tenth of a second between the Canadian and American values; the latter is based on a larger number of transcontinental routes, but this advantage is counterbalanced by the fact that the number of links is considerably greater.

It might be worth while to consider a new co-operative determination, involving one Canadian and one American station on or near each coast to be connected by single links as a simple quadrilateral, with exchange of observers in each case and with transit micrometers throughout. That single links stretching across the continent are feasible has been demonstrated time and again in our experience.

NOTES ON THE VARIABLES 9.1914 AND RT VULPECULAE.

By S. D. Townley.

The star 9.1914 was announced to be variable by Madame Ceraski in 1914. An examination of twenty-three plates taken from 1908 to 1913 showed a photographic range from magnitude 10.4 to 11.7. Thirty-four observations by the author, spread over a considerable period of time, showed a visual range of $0^m.4$.

Assuming the star to have been of constant brightness during the period of these observations, the probable error of a single observation came out to be $0^m.07$ which is somewhat larger than the probable error obtained from observation of stars of constant brightness. This would seem to indicate a real variation in brightness. The star is reddish in color and probably a variable of the irregular type.

The variation of RT Vulpeculae was announced by Asbury several years ago who found an apparent rapid decline of brightness of $0^m.5$ on two different evenings, indicating probably an Algol type of variation. Four hundred ninety-two observations by the author do not reveal any variation of the Algol type. A total range of $0^m.6$ was obtained but it has not thus far been possible to deduce any law of variation. Miss Cannon very kindly examined twenty Harvard College Observatory plates, but found no variation of the star on these. The plates were taken from October 6, 1902, to July 1, 1916.

A NEW METHOD OF OBSERVING THE POSITION OF THE CENTRE OF THE SUN.

By R. W. Willson.

At the meeting of the American Astronomical Society in Evanston in 1914 the writer exhibited a new method of observing the sun with small transit instruments (surveyors transits) by placing a very flat conical prism in front of the object glass. The angle of the cone was such that the image of the sun in the focus of the object-glass was transformed into a disc of about twice the sun's diameter with a small black spot in its center, which could be set on the cross wires of the transit with great accuracy. The error of centering of the two surfaces of the prism is eliminated in the mean of two observations between which the prism is rotated through 180 degrees about an axis perpendicular to the line of sight. This method of observation is more rapid, accurate and convenient than the ordinary practice of setting the vertical and horizontal cross wires tangent to the vertical and horizontal limbs of the sun.

The same method would be convenient for meridian observations of the sun since it requires no separate observation of the two limbs, and may therefore be made in a shorter time, and by a single measure of

both coördinates as in the case of a star, and without changing the setting in zenith distance for the declination observations on upper and lower limbs.

The correction for personal equation is probably very nearly the same as for stars. The correction for aberration of the conical surface, however, requires that the base of the prism should be given a slight negative curvature to form a satisfactory image at the stellar focus; moreover it seems probable that the variation of the size of the dark spot with the change of the sun's diameter during the year would make it necessary, or at least desirable to have several prisms of different conical angles so that one might be chosen appropriate to the date of observation.

This device was a by product of an investigation into the possibility of observing the sun with the almucantar, made some years ago. The desirability of such observations seems obvious, while the slantwise path of the sun, in the field of the almucantar, adds a further difficulty to those which affect a complete observation of both limbs of the sun with the meridian circle. All determinations of the position of the equinoctial points hitherto made depend on observations made with divided circles, while almucantar values depend only on measures of intervals of time, from which are determined the single instrumental correction which must be accurately known. In the present state of horological art, time is the easiest factor to determine with a given degree of accuracy.

For the accuracy required by almucantar or meridian observation the conical prism would hardly serve, as the expense of manufacture would be very great. A more satisfactory apparatus consists of a thin prism having a deviation slightly greater than the sun's semi-diameter placed in front of the object glass, and rotated rapidly about an axis parallel to the line of sight during the period of the observation. Immediately after the Evanston meeting, such a prism was constructed by Petitdidier and with it twenty-eight transits of the sun were observed between April 1 and June 18, 1917. About twenty of these were made under such conditions as to give a fair idea as to the practical working of the method.

The results seemed to warrant a further investigation, and, by the courtesy of Rear Admiral T. B. Howard, Superintendent of the U. S. Naval Observatory, the prism was tested on the six-inch transit-circle of that institution. It was found that observations in right ascension made by experienced observers were subject to the same probable error as the ordinary observation of both limbs. It seems probable therefore that the settings in declination would be of the same accuracy, while the single setting on the spot is obviously more convenient than the two settings on the upper and lower limbs.

It is a fair inference that such a prism applied to the almucantar would make possible accurate observations of the sun with that instrument.

THE ORBIT OF β DORADUS.

By RALPH E. WILSON.

The binary character of β Doradus ($\alpha = 5^h32^m.8$; $\delta = -62°33'$) was announced by Palmer in 1904. Its magnitude is 3.8 and its spectral classification, F5. Twelve observations taken with three-prism dispersion at Santiago, Chile, during the years 1903 to 1910 gave no indications of the period of variation. Thirty-six additional plates taken with two-prism dispersion between 1913 and 1918 showed that the period must be about 9.8 days, but the curve thru the observations was not representative of the simple elliptic motion. The earlier observations were found to fall quite uniformly on the curve representing the later after an accurate value of the period had been found. Preliminary elements for the principal variation were derived by graphical methods and the residuals were found to be satisfied by a secondary variation in a period one-half that of the primary. Least squares solutions involving the forty-eight observations give the following elements:

	Primary	Secondary
P	= 9.842 days	4.921 days
T	= J. D. 2421285.68 ± 0.05 day	J. D. 2421289.59 ± 0.04 day
e	= 0.38 ± 0.007	0.28 ± 0.02
ω	= 21°.6 ± 0°.9	56°.6 ± 3°.5
K	= 16.64 ± 0.10 km	4.55 ± 0.08 km
V_0	= +9.31 km	
$a \sin i$	= 2,084,000 km	295,600 km
$\frac{m_1^3 \sin^3 i}{(m+m_1)^2}$	= 0.0037 ⊙	0.000043 ⊙

The probable error of a single observation is ± 1.2 km per second.

The spectrum of β Doradus resembles that of the Cepheid variables. Its proper-motion, its galactic latitude, approximately —32°, the values of its period, eccentricity, longitude of node, $a \sin i$ and mass ratio approximate closely similar characteristic values in the elements of the Cepheids. No variation in its light has yet been detected. Suggestion is made that this star may be either a Cepheid with a small variation in light or a pseudo-Cepheid similar to those listed by Adams and Joy (*Publications Astronomical Society of the Pacific* **31**, 185, 119). If it is a Cepheid its absolute magnitude derived from the period-luminosity curve would be —3.1 and the resulting parallax, 0".0042.

THE ORBIT OF THE CEPHEID VARIABLE *l* CARINAE.

By RALPH E. WILSON AND C. M. HUFFER.

The star *l* Carinae ($\alpha = 9^h42^m.5$; $\delta = -62°3'$) is a well-known southern variable of the Cepheid type. Its magnitude varies between 3.6 and 5.0. In view of the recent investigations of the Cepheids and their bearing upon the structure of the sidereal universe, this star is of peculiar interest because of its comparatively long period, 35.5 days. Of the 139 Cepheids listed by Shapley (*Astrophysical Journal* **47**, 282, 1918) only two, *l* and U Carinae, have periods over thirty days. Up to the present no spectrographic elements have been published for any Cepheid with a period over eighteen days.

Albrecht has shown that the spectrum of *l* Carinae varies from F8 at or near light maximum to G5 at or near light minimum. Shapley gives the absolute magnitude derived from his period-luminosity curve as —5.1 and the resulting parallax, 0".0013.

Three series of spectrograms taken at the Southern Station of the Lick Observatory, Santiago, Chile, in the years 1904, 1907, and 1917, totaling thirty-two, were available for the computation of the orbit. Roberts' period of light variation was found to satisfy the observations best. The following elements are derived:

$$
\begin{aligned}
P &= 35.523 \text{ days (Roberts, assumed)} \\
T &= \text{J. D. } 2417636.76 \pm 0.29 \text{ day} \\
e &= 0.36 \pm 0.015 \\
\omega &= 99°.5 \pm 3°.4 \\
K &= 18.86 \text{ km} \\
V_0 &= +4.10 \text{ km} \\
a \sin i &= 8{,}593{,}000 \text{ km} \\
\frac{m_1^3 \sin^3 i}{(m + m_1)^2} &= 0.0210 \odot
\end{aligned}
$$

The probable error of a single observation is +1.0 km per second. Minimum velocity is found to occur 3.3 days before maximum light. The elements are typical of Cepheid variation, the large values of $a \sin i$ and the mass ratio being for the most part due to the size of the period.

THE ORBIT OF θ^1 SAGITTARII.

By RALPH E. WILSON AND C. M. HUFFER.

The binary character of θ^1 Sagittarii ($\alpha = 19^h53^m.2$; $\delta = -35°35'$) was announced by Paddock in 1910. Its magnitude is 4.4 and its spectral classification, B3. In the region λ4000 to λ4600A there are about ten measurable lines, five of which are generally good. Thirty-four plates taken at Santiago, Chile, give the following elements:

$$P = 2.10514 \text{ days}$$
$$T = \text{J. D. } 2411140.645 \pm 0.010 \text{ day}$$
$$e = 0.0$$
$$K = 15.9 \pm 0.5 \text{ km}$$
$$V_0 = +0.9 \pm 0.2 \text{ km}$$
$$a \sin i = 460{,}000 \text{ km}$$
$$\frac{m_1^3 \sin^3 i}{(m + m_1)^2} = 0.00088 \odot$$

The probable error of a single observation is ± 1.2 km per second.

N. B.—The three foregoing papers will be published in full in the *Lick Observatory Bulletins.*

THE ORBIT OF THE SPECTROSCOPIC BINARY H. R. 8800.

By Reynold K. Young.

Star number 8800 in the Revised Harvard Photometry (α 1900, $23^h 02^m.6$, $\delta + 45° 34'$) was discovered by the writer to be a spectroscopic binary in 1918. The early plates indicated stationary values for the H and K lines and an orbit was undertaken. The star is approximately B3 type. The lines are all rather poor, including K, though the latter is better than the others. The hydrogen and helium lines show evidence of complexity but on none of the plates was the companion line deemed sufficiently trustworthy to measure. The orbital elements given below are only approximate as a least squares solution has not been undertaken.

$$P = 3.337 \text{ days}$$
$$e = 0.20$$
$$\omega = 120°$$
$$K = 90 \text{ km}$$
$$\gamma = -16.2 \text{ km}$$
$$T = \text{J. D. } 2422151.200$$
$$\text{Velocity from calcium lines} = -9.1 \text{ km}$$
$$\text{Velocity of sun towards star} = -12 \text{ km.}$$

THE STATIONARY CALCIUM LINES IN EARLY TYPE STARS.

By Reynold K. Young.

At the present time there is considerable material bearing on this subject scattered through the periodicals and the paper of which this is a synopsis collects this in tabular form. There are about forty stars known to the writer which show the phenomenon and from them some interesting facts can be learned.

All the stars are of type B3 or earlier. Very few are as late as B3. One or two stars which have been published as showing the phenomenon later than B3 are either wrongly classified as to type or the abnor-

mal behavior of the calcium is not well established. Two stars listed as type A certainly should be omitted. Conversely nearly all stars as early as B2, if they are binary, show H and K stationary or giving a smaller range than the other lines. This is good evidence that the calcium vapor is connected with the star as part of its life history whether as a cloud in which the star is enmeshed or as a part of its reversing layer.

As a rule the hydrogen and helium lines are rather wide and diffuse and the H and K lines sharp and narrow but this is not always the case. Some stars are known in which all the lines including K are rather poor and some in which all are fairly sharp. One is justified in believing that when the H and K lines are very sharp and narrow while the other lines are wide and diffuse the calcium vapor is in a much more tenuous and quiescent state than the hydrogen and helium causing the wide and diffuse line.

The velocity of the centre of gravity as determined from the calcium lines often differs both from the centre of gravity of the system as determined from the other lines and also from the component of the solar motion toward the star. It agrees (or disagrees) with the one as well as the other. The simplest way to adjust these discordances is to assume the wave-lengths of the lines to vary from star to star. The extreme variation is about twenty kilometers and we have examples of other lines displaced this amount from their normal positions, e. g., the silicon lines in P Cygni.

It is quite probable that the calcium is not displaced greatly from its normal position and that the discordances are due to the displacement of the *other* lines. The reasons for this belief are two. Firstly, the H and K lines probably have their origin in gases at low pressure and are therefore likely to be less affected by such circumstances; and secondly, it is often those stars which have the widest diffuse lines which show the largest discordances. They give high velocities for early type stars from the hydrogen and helium but quite normal velocities from H and K.

The star 12 Lacertae gives strong evidence that the calcium vapor moves with the star. In this case the velocity of the centre of gravity as determined from year to year undergoes a slow change. In 1913 it was —8.5 km and by 1918 it had decreased to —19.1 km. The mean velocity of the calcium lines shows the same decrease.

The sharp H and K lines in novae as well as the D_1 and D_2 lines show the conditions there to be similar to that in the B-type stars but the fact that the latter are not novae and are not variable gives additional evidence that the star is at rest relatively to the cloud.

A plot of the early and late B-type stars shows that all occupy the same general regions of space and hence that the nebulosity which surrounds the stars and produces the H and K lines is not the extended nebulosity such as is seen on the background of the Orion and Cygnus

regions. In support of this contention we have the Pleiades, a group of stars well known to be enmeshed in nebulosity but giving no sharp H and K lines. They are mostly of B5 type which is too late to show the effect.

Two stars of early B-type only a few seconds of arc apart recently photographed by H. H. Plaskett show quite different calcium lines. The one of earlier type shows narrow and sharp H and K and the later B-type shows H and K rather wide and much like the other lines in the spectrum. This shows that the calcium cloud subtends a very small angle.

In several stars it appears that in addition to the stationary H and K lines, there often is another line near K which when measured oscillates with the hydrogen and helium lines. This result is not well established yet and should be investigated further but it gives every evidence of being true.

In view of all the foregoing facts, the writer proposes the following hypothesis. The early type stars, B2 or earlier but sometimes as late as B3, are surrounded by a huge cloud of vapor in which are found the elements sodium and calcium in sufficient quantities to produce absorption. This cloud is an integral part of the life history of the star but at first is not a part of the reversing layer which has much smaller dimensions. The cloud, however, subtends at the observer a small and at present unknown angle. The calcium absorption in the reversing layer of the early B-type stars is practically absent and when such stars are binaries, they show the large oscillating components of the hydrogen and helium lines and a narrow H and K due to the calcium envelope. The general line of progression of these stars is toward an absorption of the surrounding cloud into the centre. The effect on the calcium lines is to produce both the stationary and oscillating components. The calcium in the reversing layer is subjected to all the turmoil and conditions that affect the hydrogen and helium and this component has much the same nature as these. At the same time the blending effect can produce the part range sometimes exhibited by the calcium lines. As the vapor is absorbed into the reversing layer this line grows strong and the envelope line weaker till finally the calcium line shown on the spectrogram is of the same character as that due to the other elements.

REPORTS OF COMMITTEES.

REPORT OF THE ECLIPSE COMMITTEE.

Meteorological observations taken in the usual way at 8 A. M., noon and 8 P. M., are frequently inadequate in the determination of a favorable site for an eclipse station. In Russia, in 1914, the meteorological data proved misleading because of the fact that the maximum cloudi-

ness of the day came at 3 P. M., the hour of the eclipse.

Through the cordial coöperation of Senor Joaquin Gallo, a member of this committee, the Mexican Government has at our request already initiated special meteorological observations along the path of the eclipse of September 10, 1923, and will secure for the first fifteen days in September each year till 1923 data as to cloudiness, etc., obtaining at various stations in Mexico on the shadow path, taken *at the hour of the eclipse*. We have suggested to the Government of Queensland that similar observations, at the hour of the eclipse, be carried out this year and next, in preparation for the eclipse of September 20, 1922, in the region about Cunnamulla.

The committee proposes, after sufficient data, now being collected for the eclipses of 1922 and 1923, are available,—

a) To publish such information in accessible form for intending observers.

b) To suggest the lines of work most needed.

c) To offer its services to intending observers as a clearinghouse in arranging for loans of instruments and apparatus, and,

d) To compile a list of proposed American and foreign expeditions for the Mexican eclipse of 1923, and to offer its services, if requested, as an advisory board to secure a wide distribution of stations.

It is felt by the committee that it is still too early to exercise the functions described above, inasmuch as but few observatories or individuals will have made definite decision as yet with regard to participation in the eclipse observations of 1922 and 1923.

HEBER D. CURTIS, *Chairman*, Allegheny Observatory.
E. E. BARNARD, Yerkes Observatory.
F. B. LITTELL, U. S. Naval Observatory.
S. A. MITCHELL, Leander McCormick Observatory.
W. J. HUMPHREYS, U. S. Weather Bureau.
JOAQUIN GALLO, Tacubaya Observatory.

REPORT OF THE COMMITTEE ON METEORS.

By CHARLES P. OLIVIER, *Chairman.*

The principal step forward, made during the past year with respect to meteoric astronomy, was the formation of a "Committee on Meteors" by the International Astronomical Union. This committee has as chairman the eminent English astronomer, Mr. W. F. Denning. He has already sent out circulars, as well as personal letters, in an attempt to organize more thoroughly meteor work throughout the world. It is hoped that some of the recommendations, made through the Committee on Meteors of the American Astronomical Society and adopted by

the Society in recent years, will also be adopted by the International Committee, as they have been submitted for consideration.

So far as known little progress has been made in actual observation of meteors in America during the past year. However, your chairman has at last completed the working up of the results of 22,000 observations reported by the American Meteor Society from 1914-18, and the publication of these results should appear by the end of 1920. The discussion of the results has shown very forcibly that the question of stationary radiants, and probably the real heights of meteors, cannot be solved with precision by present methods. All interested in meteoric astronomy look eagerly forward to the development of photographic methods which will be adequate. Experiments on these methods are now being made in England, where there is at present a great revival of interest in meteors.

It should be urged, however, that observations made by experienced observers, without instrumental aid, are continually necessary and are quite adequate to give data as to the richness, periodicity, and general characteristics of meteor streams, as well as to determine with considerable precision their radiants.

The committee desires to make the following request of members of the American Astronomical Society on behalf of the American Meteor Society, which latter it is to be understood works in accord with the directions and recommendations of your committee.

(1) That observers, who are willing to give this slight aid, will kindly note the magnitudes of all telescopic meteors seen during the next year, and report the same to the American Meteor Society.

(2) That astronomers make some effort to collect observations of meteorites and brilliant fireballs when they are first reported in the press, as is being successfully done in England, so that their paths may be computed. Large numbers are yearly reported in America, but rarely are accurate enough observations secured to make this possible.

(3) That teachers of astronomy will use their influence with students and amateurs toward interesting them in the observation and study of meteors.

Finally it may be said that if astronomers will take the first two of these requests seriously and give their active coöperation, real progress in both lines may be expected.

REPORT OF THE COMMITTEE ON VARIABLE STAR OBSERVATIONS.

By Leon Campbell, *Chairman.*

In securing future observations of variable stars, it would seem that the long period variables, and some of the more interesting irregular variables, are being very well taken care of by the American Associa-

tion of Variable Star Observers. There seems little need for this committee to concern itself with this class of stars.

A knowledge of what is being done on the other classes of variables, such as the eclipsing stars, the Cepheids, and the cluster type, still seems to be desirable, if we are to be assured that they will be sufficiently well observed. Also, as has been suggested in previous reports, a canvass of the telescopes of this country, say, larger than four inches aperture, might be helpful in ascertaining where they are, as well as to the possibility of having them brought into good use by experienced observers.

It is therefore proposed that a circular letter be sent to each member, with the request that information on these two points be supplied for the future consideration of the committee.

The variable star field is a large one and much work remains to be done therein. The committee requests the aid of the members and the Council of the Society with suggestions for its future guidance, if continued progress is to be made in this line.

THE APPARENT CONCENTRATION OF SPIRAL NEBULAE NEAR THE GALACTIC POLES—AN ILLUSION.

By JOHN CANDEE DEAN.

The extent and structure of the stellar universe is now the paramount topic of discussion among astronomers. Knowledge of the great star clusters, and of the spiral nebulae, has undergone such very rapid extensions that astronomers themselves have been astonished. Until recently, few attempts had been made to penetrate space beyond the depths of our own galaxy of stars, and the belief was common that the material universe did not extend beyond our galaxy.

When we stand in the open country on any clear moonless night and view the great canopy of the heavens, all stars that we behold are connected with, and belong to our Milky Way system of stars. With large modern telescopes, astronomers have been enabled to penetrate the depths of space far beyond the outer regions of our Milky Way, and to photograph objects that are thought to be exterior universes. So thickly is the background of space studded with spiral nebulae, that perhaps there are a million of these, so-called, "Island Universes" within the range of the camera of big telescopes. So remote are they, it is estimated that 1,000,000 to 10,000,000 years are required for their light to traverse the vast abyss that separates us from them.

Curtis states that if our galaxy were viewed from the distant spir-

als it would probably measure about ten seconds of arc, which is about the size of the larger spirals measured by us from the earth.

The strongest evidence that the spiral are composed of stars is the fact that their spectra are practically the same as those of known star clusters, therefore, if our telescopes were of sufficient power, the spirals would probably be resolved into star galaxies, similar to our own. It is probable that it would require more than 200,000 years for a beam of light to pass through the larger diameter of our galaxy, and those spirals that have a diameter of ten seconds would require about the same time for the passage of light through them.

Curtis uses the new stars, which have appeared in the spiral nebulae, for computing the distance of the spirals. These new stars have averaged about the eighteenth magnitude. The new stars which have appeared in our galaxy, are estimated at the fifth magnitude, with an average distance of perhaps 10,000 light years. Assuming that both novae are of the same absolute magnitude, the difference in their apparent magnitude would indicate that the novae in the spirals are 160,000 times fainter than those in our galaxy, hence their distance would be in the order of 4,000,000 light years. The distance he regards as moderate, and he later says, "A comparison of the average magnitude of the novae in spirals, with those of our own galaxy indicates a distance in the order of 10,000,000 light years for the spirals."

The heretofore inexplicable feature of the arrangement of the spirals, or Island Universes, has been found in their anomalous concentration at the poles of the galaxy and disappearance as the plane of the galaxy is approached. Careful observations have shown that there is an average of 34 spirals per square degree in regions within 45 degrees of the poles, while in a zone 60 degrees wide near the plane of the galaxy there are only seven to the square degree and none are found in the milky way itself. In other words, the spirals are concentrated near the galactic poles and disappear as the galactic plane is approached.

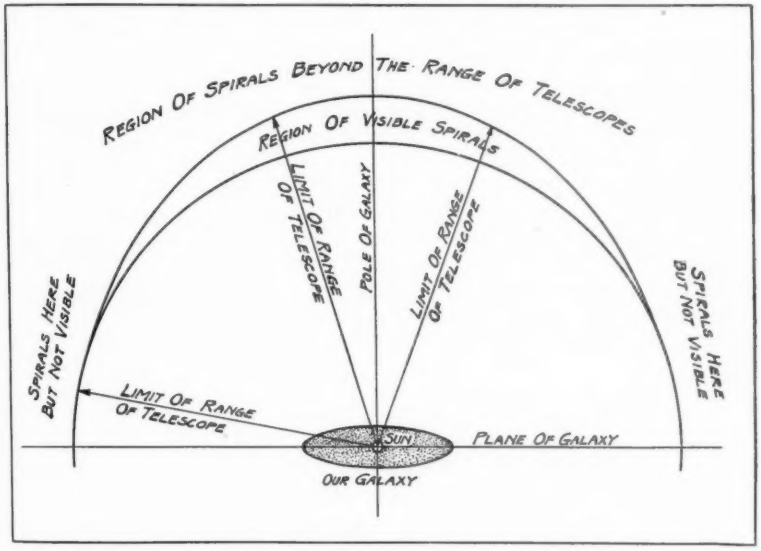
The spirals are not only at vast distances from us, but must necessarily be at vast distances from each other, otherwise they would be disrupted by collision produced by mutual gravitational attraction. The nebula of Andromeda is probably the nearest of the spirals. Moulton made a calculation of the gravitational pull, on the earth, of the nebula, by assuming its parallax to be one one-hundredth of a second. He says, "Suppose its apparent dimensions were only as great as that of the sun, and assume for simplicity that it is spherical like the sun. Even if the nebula is $\frac{1}{20{,}000{,}000}$ as dense as the sun, it attracts the earth as much as the sun does." Its distance, therefore, must be vastly greater than that assumed by Moulton.

We must think of our galaxy as a companion of the spirals seen in

the telescope, and that we are probably as near to our nearest spirals as they are to each other. We, also, naturally assume that the universe of spirals is stable. If there were a tendency to draw into each other, they would have coalesced long ago, and formed into enormous aggregations. They are probably moving in straight lines, because their enormous velocity, of nearly 500 miles a second, would give them a momentum which would prevent them from being sensibly deflected by the gravitational pull of the nearer spirals.

Our galaxy is estimated to be spread out in the form of a flat circular disc, with a diameter of perhaps 200,000 light years, and a thickness of perhaps 40,000 light years. It is thought that the sun is near the center of our galaxy.

In a lecture delivered at Washington, D. C., last year, by Heber D. Curtis, he says, "No spiral has yet been found actually within the structure of the Milky Way. We have doubled and trebled our ex-


REGION OF SPIRALS BEYOND THE RANGE OF TELESCOPES
REGION OF VISIBLE SPIRALS
LIMIT OF RANGE OF TELESCOPE
POLE OF GALAXY
LIMIT OF RANGE OF TELESCOPE
SPIRALS HERE BUT NOT VISIBLE
SPIRALS HERE BUT NOT VISIBLE
LIMIT OF RANGE OF TELESCOPE
SUN
PLANE OF GALAXY
OUR GALAXY

THE DRAWING SHOWS WHY THE APPARENT CONCENTRATION OF SPIRAL NEBULAE AT THE GALACTIC POLES IS AN ILLUSION

posures in the regions, near the galactic plane in the hope of finding fainter spirals in such areas, but thus far without results. The outstanding feature of the space distribution of the spirals is, then, that they are found in greatest profusion where the stars are fewest, and do not occur where the stars are most numerous."

If we assume that the above is a true theory of the arrangement of the spirals, we must also assume that there are strong physical re-

lations between the spirals and our galaxy, physical connections so powerful that the spirals are dominated in their grouping by forces existing in our universe. Such a theory would be absurd if we adhere to the opinion that each one of the distant spirals approximates in size that of our own galaxy of stars.

The drawing illustrates the writer's theory as to the cause of the gradual disappearance of spirals, as the plane of our galaxy is approached. It is the writer's opinion that the spirals are quite uniformally distributed in space. Our own galaxy is so filled with matter that it obstructs the view of spirals near its plane. There are not only the visible stars and nebulae, bright and dark, but there is diffuse matter scattered through all our galactic space. This matter has been estimated to be in the aggregate mass, greater than is contained in all the stars. There are also supposed to be more dark invisible stars than luminous ones.

When looking toward the poles of the galaxy, we are looking through its thinest section. When looking at an angle of 30 degrees from its plane, the view is obstructed by more than three times the density of occulting matter, and when looking near the plane of the Milky Way, the view is obstructed by a galactic mist of occulting matter, five or six times as dense as when looking toward the poles; hence, these distant spirals are shut out of view, near to, and in, the galactic plane.

Therefore, the grouping of the spirals at the poles of the galaxy is an optical illusion. If our galaxy were in the form of a globular cluster, the spirals would doubtless be seen quite uniformly distributed in all directions.

The drawing shows a hemispheric section of the heavens; the other hemispheric section would be an exact duplicate.

University Club, Indianapolis. Nov. 13, 1920.

THE ZODIACAL TEMPLES OF UXMAL.

By STANSBURY HAGAR.

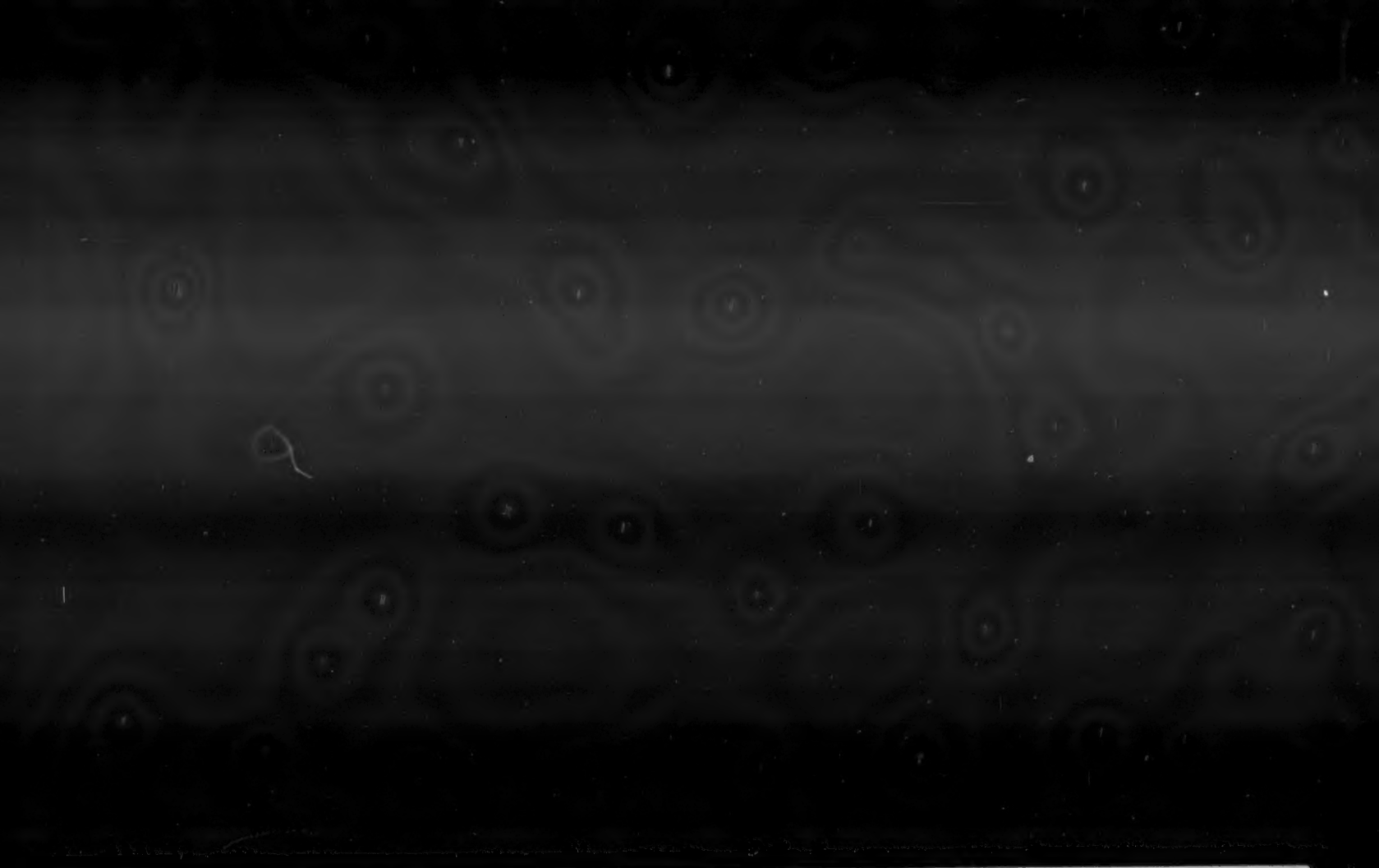
On our own continent of America, there is an interesting field of study in which astronomy in alliance with archaeology teaches us much concerning the most advanced thought of the ancient peoples of America as revealed in the symbols of their art, architecture, literature and religion. The fascinating and usually accurate works of Prescott have taught us that the ancient Mexicans and Peruvians had attained to some advancement in those subjects and that the former people possessed a rudimentary literature. But it is one of the in-

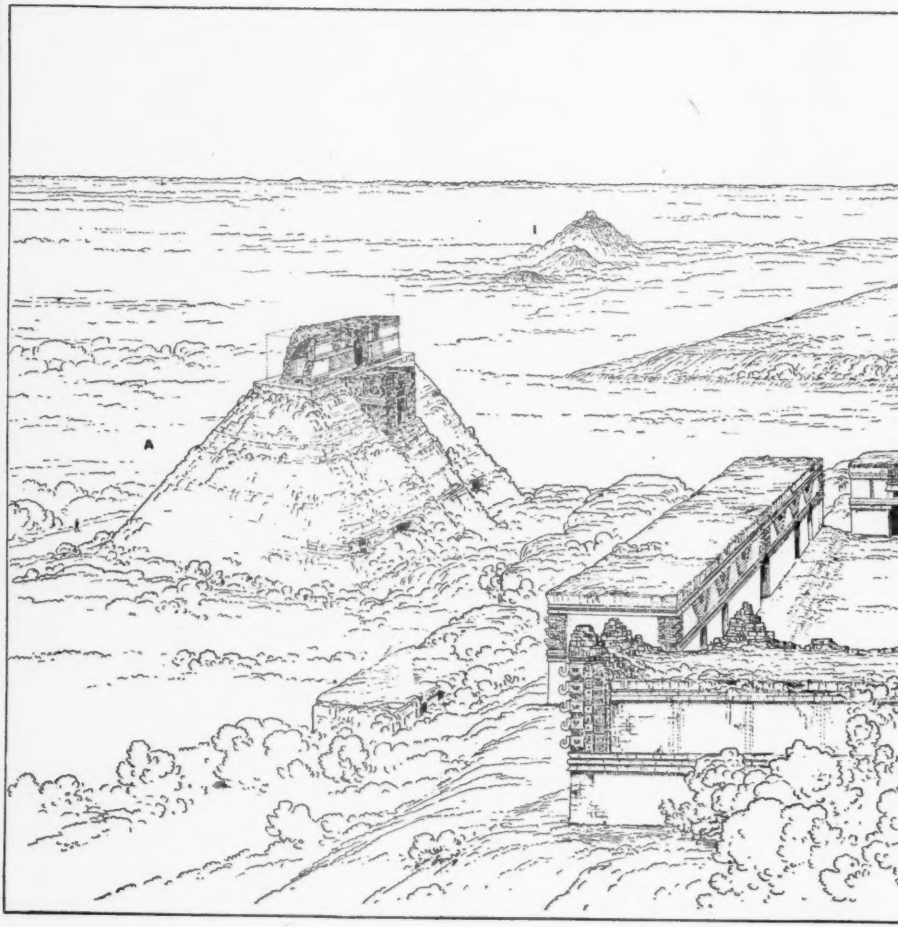
justices of history that the romantic incidents of the conquest of Mexico and Peru have almost concealed from our sight the knowledge of the most advanced people of ancient America, the Maya of Yucatan, Central America and parts of southern Mexico. Perhaps a hundred of their cities, and a thousand stone temples and other monuments are scattered through the tropic forests that now cover the greater part of their former domain, and no two alike, for the Maya had highly developed the love of individual initiative which charaterizes a democratic, freedom-loving people. They were, indeed, the great architects and builders of America unrivalled on this continent save by their relatives, the shadowy Toltecs of Mexico and by the equally shadowy pre-Inca culture of Peru derived from Tiahuanacu on the lofty plateau of Lake Titicaca. Many of the Maya temples were covered inside and out with elaborate, lozenge-shaped hieroglyphics, with sculptures and mural paintings displaying an evident love of art and beauty of such quality that one authority views their art as superior to all save that of the Greeks in the ancient world. They also possessed hundreds, perhaps thousands, of books on deer-skin and maguey paper, filled with paintings and hieroglyphic texts, which differed but slightly from those on the temples and monuments. Most unfortunately nearly all these books were deliberately destroyed by the priests who accompanied the Spanish conquerors to obliterate the memory of the native religion, the logical result of the belief that there is but one path towards spiritual advancement. But three Maya codices, hidden in private and public collections of Europe, escaped the intolerant priests and already have afforded us invaluable aid in studying the meaning of the Maya glyphs. Our knowledge of those glyphs is still far from complete and must long remain so for no acceptable explanation of them has reached us except Bishop Landa's identification of the uinal month and the twenty days that compose it. We have had to give up hope that any living descendant of the Maya can now interpret the glyphs. There is no hope of finding a Maya Rosetta stone and very little, of finding an ancient manuscript which will supplement Landa. So we must probably hew out the meaning of the glyphs one by one by main force, as it were. Some progress has been made in this direction. We have learned the glyphs of numbers, periods of years, deities and animals, also of the apparent periods of revolution of Venus and other planets, for the Maya had noted these periods with astonishing accuracy evidently as the result of long continued patient observation. These results confirm earlier impressions that the Maya glyphs are concerned almost entirely with numbers, time periods, religious festivals and astronomy. We have learned that when the Spanish conquerors entered Yucatan, the Maya were on the verge of establishing a phonetic alphabet. They possessed a calendar superior to that of Europe at the time, used numeration by position and recognized a zero glyph. Their dated monuments carry us back with cer-

tainty to at least 100 B. C., but their civilization is probably much older. We know that the climax of their culture was attained about 600 A. D., followed by a renaissance culminating about 1200 A. D. and ending in destructive civil wars that continued till the coming of the Spaniards.* Language shows that the Aztecs of Mexico were related to the Uto-Aztecan family which includes our modern Utes, but the Maya have no known linguistic affinity with any other existing American people. We know nothing as to when or whence they came into their land. So much for our general knowledge of them.

There is no doubt that astronomy played a very important role in Maya culture, but how great it was we have only begun to apprehend. Dr. Seler pointed out that certain figures in the Maya codices and on certain temples pertained to constellations with which the planet Venus is in conjunction. The author has shown in papers published in the American Anthropologist and the International Congress of Americanists that these symmbols, as well as others found in sequence in codices, calendar divisions and rituals, refer to the two forms of the Maya zodiac, one the normal zodiac of twelve signs, the other divided in twenty parts governed by the twenty days of the uinal month in sequence. The symbols of both these zodiacs are so similar to those of our own zodiac as fully to justify the statement that they were probably derived from the same source even though we do not know when, where or how the communication occurred. At least they were certainly known to the Maya centuries before Columbus discovered America, and probably from the earliest times of their civilization. But, from the writer's viewpoint, by far the most interesting aspect of this native zodiac is found in the discovery that many and perhaps all of the Maya cities were planned to reflect on earth the supposed design of the heavens, that is each temple of the principal group was dedicated to one of the zodiacal signs and its position relative to the other temples corresponded with the relative position of the zodiacal asterisms. In one month certainly and each month probably, a procession of masked men before the temples represented the passage of the sun through the zodiac. The symmetrical and very elaborate designs on some of the temples have already convinced scholars that these structures must have been erected from architects' models but the celestial plan shows that the topography of the entire city was studied and planned before a temple was erected so that the zodiacal scheme might be completed within the limits of the site. The symbols of each temple pertain to the sign to which it is dedicated. Each had its own class of priests, its own special offerings, and in each special prayers were offered in accord with the attributes of its sign. Prayers for good crops were offered in the temple of the sign of rains and crops, for success in hunting in the temple of the hunting sign, etc. This cosmic and as-

*See Morley in Bib. Note.





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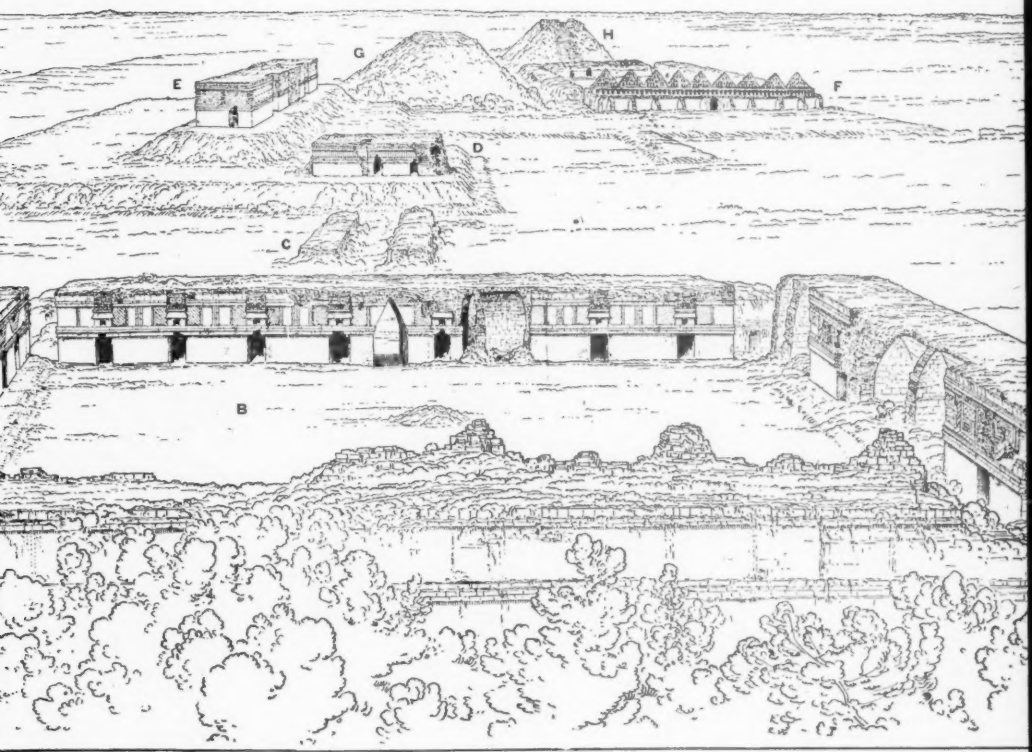

FIGURE 1.

PANORAMA OF UXMAL. HOLMES.

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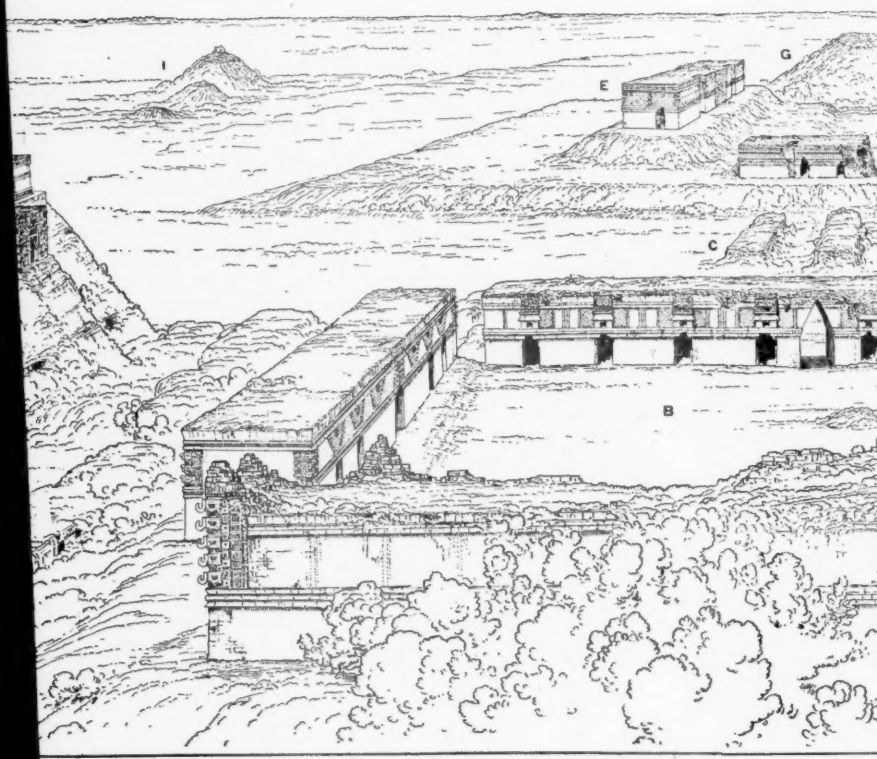

FIGURE 1.

PANORAMA OF UXMAL. HOLMES.

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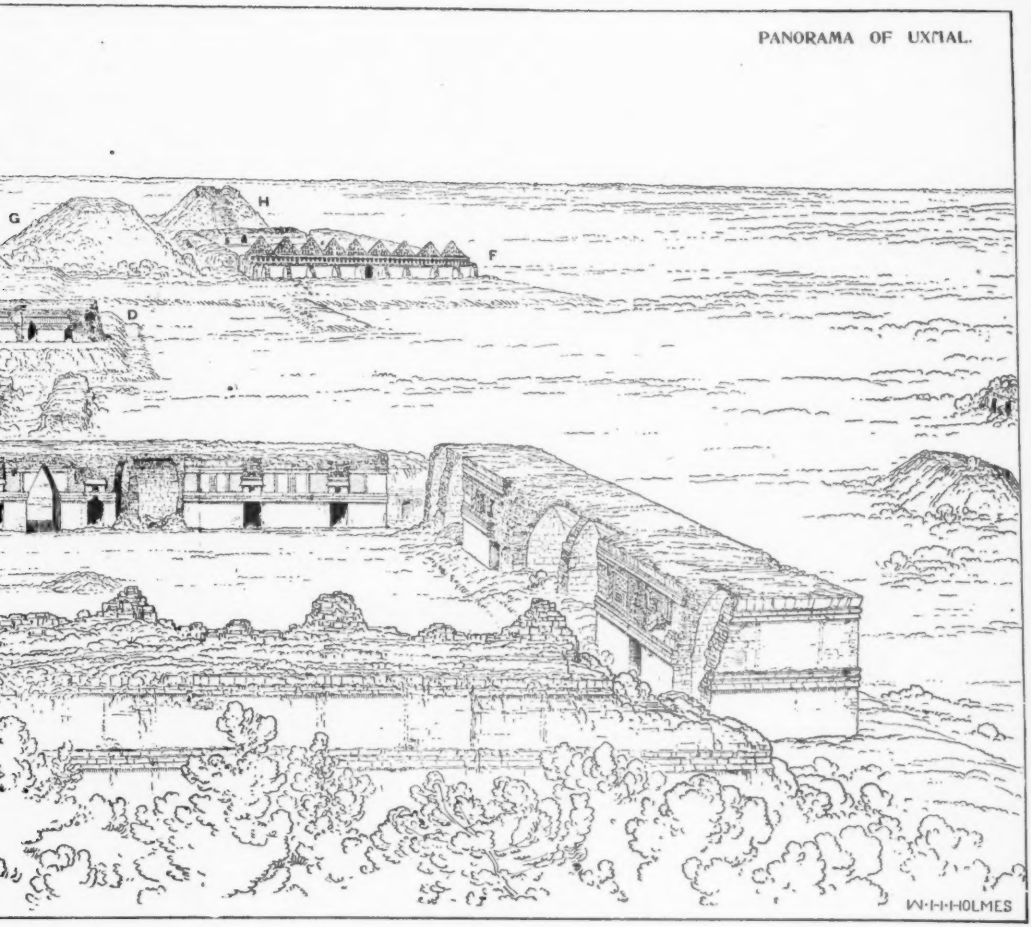

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Museum of Natural History, Chicago.)

tronomic motive of celestial imitation is, in fact, the basic concept which has brought about the development of the extensive Maya symbolism, art, architecture and religion. Where else has astronomy played so important a role in the advance of a people to civilization?

The Maya temples are now in all degrees of ruin from the growth of destructive tropic vegetation and the devasting hand of man, but in four places—Uxmal, Chichen Itza, Yaxchilan and Palenque—an almost complete zodiacal sequence can be recognized and sequences of varying extent are seen in many other places including the temples and stelae of Copan and Quirigua, the oldest known Maya ruins. For our purpose, it should suffice to describe the principal features that enable us to apprehend the celestial plan at Uxmal, the most modern and best preserved Maya city, founded about 1000 A. D. in northern Yucatan. Practically all Maya temples are built on platforms at the top of pyramidal mounds. Some of their designs are cut on stone, others are carved in stucco. Many symbols are repeated on numerous temples but each temple has its distinctive symbols usually conspicuous both by form and position and the traditional names of the temples help us somewhat. There had been quite an extensive interchange of symbols between the Maya and the neighboring Mexican peoples, so we shall encounter symbols of both at Uxmal.

Near the southwest corner of the Plan the sequence begins with Aries, the first sign of our zodiac. The only circular sacrificial stone at Uxmal was found at the center of the courtyard of the Southwest temple. These stones were used only in a Maya and Mexican gladiatorial combat between a warrior and a captive tied upon the stone. The combat took place while the sun was passing through the sign Aries and symbolized the renewal of the earth and of vegetation in the springtime.

The northern building of the quadrangle adjoining the Aries temple on the north is known as the House of Pigeons from the eight or nine large castellated and perforated terraces which form its roof comb and suggest the form of a pigeon house. This is the Mexican mixoyotl or cloud symbol used as such by the Maya as well as by the Pueblo tribes of our own country. The temple is then the Cloud House of the Rain God in which the clouds gather later to fall upon the maize crops in fructifying showers. It is under the influence of Taurus and the Pleiades, the stars of the rains and crops among the Maya as in all parts of the world. When the sun was passing through Taurus the Maya sowed their maize and prayed for the coming of the rains.

The structure known as the Great Pyramid is located directly east of the Quadrangle of the Pigeons but no temple seems to have been erected upon it. Charnay describes the neighboring temple towards the north-east as the most extensive, best known, and most magnificent monument in Central America. It is known as the House of

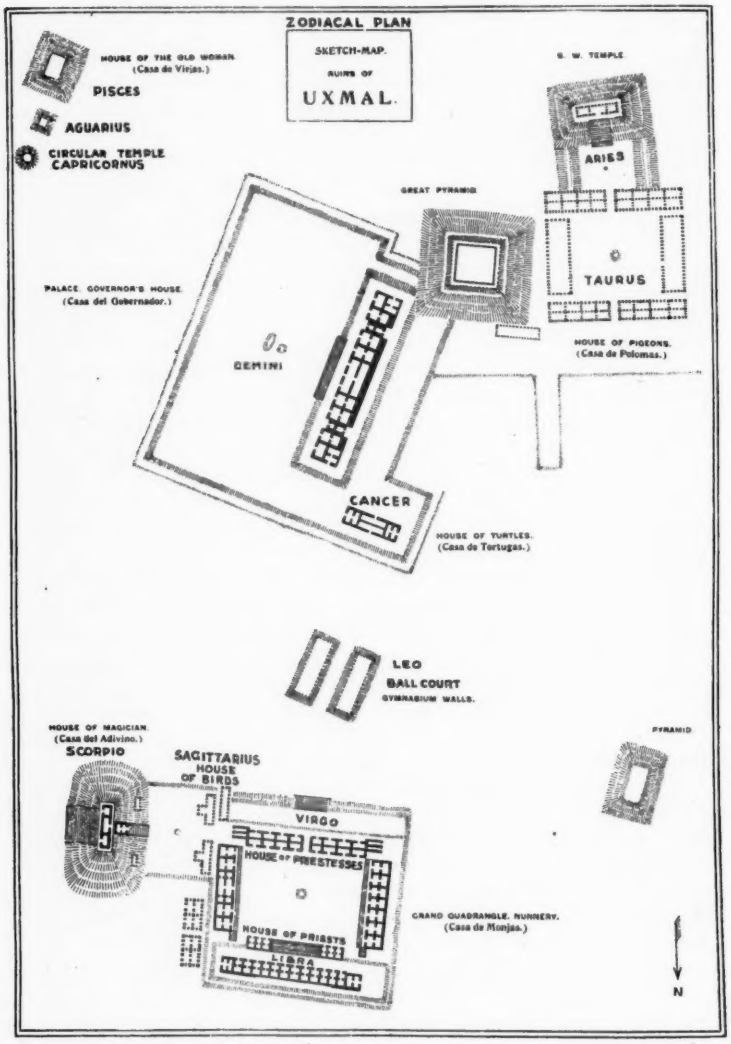

FIGURE 2.

ZODIACAL PLAN OF UXMAL.*

*Based on Holmes' Sketch Map used by kind permission of the Director of the Field Museum of Natural History, Chicago.

the Governor because the ruler of Uxmal is supposed to have resided in it. We know from tradition connected with corresponding structures at Chichen Itza and Mayapan and at Tula in Mexico that the temple was dedicated to Kukulcan, the Bird-Serpent deity known to the Mexicans as Quetzalcouatl. He was the first governor of Maya, and Mexican tradition and the basic significance of his Mexican name is the Celestial Twin. His twin serpents extend over the entire facade and his symbols occupy the position of Gemini in Maya zodiacs at Acanceh and Santa Rita, therefore the House of the Governor was dedicated to the sign Gemini.

North of the Governor's temple on the same platform is the House of Turtles so called from a row of turtles figured at intervals on the four sides of its facade. This temple is placed in the position of Cancer on a zodiacal sheet of the Maya Codex Madrid and Dr. Fostemann has identified the turtle with the summer solstice under that sign.

Northeast of the House of the Turtles, in turn, we see the parallel walls of the Ball Court ("Gymnasium") in which the national ball game of the Maya and Mexicans was played. Citlal Tlachtli, the Ball Court Asterism of the Mexicans, occupies the position of Leo among the five zodiacal asterisms which the Mexican ruler was exhorted to rise at midnight to observe. It is ruled by the jaguar deity who also gives his name to the constellation. The most important Maya mural painting is found within the Jaguar Temple attached to the Ball Court at Chichen Itza. It depicts a procession in honor of the Sun in the Jaguar asterism. The sun god sits within the solar orb on a throne supported on the backs of two jaguars. The glyph of Pop, uinal-month of Leo, is merely a cursive form of this group.

North of the Ball Court, again, is a quadrangle formed by four buildings known as the Nunnery because it was inhabited by vestal virgins who attended the sacred fires. In fact, however, they represented the female element in nature and performed all the functions appropriate to it. The southern building only of this group pertained to them. Its principal symbols were the trellis work denoting the female sex and the miniature temples on its facade representing the Calli or home in the west to which the husband returns with the setting sun. It occupies part of Virgo in the Mexican vigesimal zodiac of the day-signs. The real Nunnery was, then, the temple of the Maya female sign, our Virgo. It was ruled by the Maize God and the Mother Goddess.

The northern temple of the Nunnery group seems to have been the headquarters of the priests, the House of Priests being the typical Libra temple found at a number of Maya ruins. Within it figures of men, probably priests, seem to be playing on musical instruments and on its facade are phalli and groups of six serpents covered with the cross-hatching which characterizes the glyph of Chicchan, day-sign of Libra.

Adjoining the Nunnery Quadrangle on the southeast is a remarkable temple placed on the highest pyramidal mound at Uxmal. It is known as the House of the Magician or Prophet and Stephens describes it as the holiest of their holy places. Skulls and cross-bones on its facade define it as the Temple of Death and the legend of the Magician connected with it establishes its dedication to the Death God. The large doorway of its western facade forms the open mouth and teeth of a huge human face through which all must pass who enter the building. It represents the mighty Chilan or Speaker, the oracular priest of the Death God, who announces the wisdom obtained from communion with the living dead, for only through the doorway of death can the suppliant obtain the wisdom of this master-priest. In the Maya and Mexican codices he is represented seated on a throne before a brazier with a sinuous scroll, symbol of speech, issuing from his mouth. In the Mexican Borgian and Vaticanus Codices he sits before a stream of water, the Milky Way, in which a scorpion, our Libra and Scorpio, is swimming, for the Maya and Mexican Scorpion asterism like that of the ancient Peruvians and Greeks, included both constellations. The House of the Magician then was dedicated to the death sign, Scorpio. It might more accurately be called the House of the Oracle of the Living Dead.

Nestling against part of the eastern side of the Nunnery Quadrangle on a lower terrace is the temple called the House of Birds because of the figures of birds and feathers that cover its roof. It is the Eagle or Eagle-Down House which symbolizes Sagittarius in a lengthy sequence of pictures of zodiacal temples in the Borgian Codex. It contains the largest chambers at Uxmal which were probably used as military headquarters. The sign is ruled by the God of War and Hunting who appears opposite the Chilan in the Borgian drawing mentioned above.

An extensive vacant space separates this temple from the ruins of the next zodiacal structure far to the southeast. There we find remains of the only circular building at Uxmal. It is completely ruined but its circular form enables us to identify it with the Caracol or Snail Temple of Chichen Itza. Dr. Forstemann has rightly identified the snail with the winter solstice, therefore it stands for the sign Capricornus.

The temple of Aquarius is the only temple missing in the zodiacal sequence at Uxmal. A small ruined temple occupies the proper position to represent this sign but nothing is known of its symbols. At Chichen Itza, the Aquarius temple is placed beside the great Cenote or Sacred Pool. It was used in an elaborate sacrifice to the waters under that sign.

Finally the series of Zodiacal temples ends at Uxmal with the last temple towards the southeast known as the House of the Old Woman from a statue found in its debris which has now disappeared. The

Old Woman is the Maya Xnuc, She of the Knot, who, with her knot, represents Pisces in the zodiac at Santa Rita and in the codices. The summer signs of the Maya are governed by youthful deities, those of winter by aged deities thus apparently indicating a mystic comparison of the passage of the sun through the zodiac with the passage of the human soul through life. The ancient peoples of Peru, Arabia and the Euphratean region also knew Pisces as the Knot, and the Knot of the Fishes has come down to us in our own zodiac.

It is probable that some temples at Uxmal, as at other Maya ruins, have been erected at quite different dates from others but this does not affect the zodiacal scheme. It merely indicates that later structures have replaced older structures with similar attributes. The House of Nuns at Chichen Itza affords an example of this.

This great cosmic scheme was based upon the belief that. everything in this world is the shadow or reflection of the perfect reality that exists in the celestial realms. Imitation of the observed celestial plan therefore brings down upon earth some of the celestial perfection. The sacred celestially planned city partakes of that perfection and casts upon the inhabitants the beneficent influences from the stars. But, beyond that, the principle of celestial imitation itself is but the outer form of that religion of cosmic law and principle which has been understood by the earnest and instructed few wherever and whenever man has risen above savagery.

The planning and execution of this great cosmic scheme, to the author's mind, at least, entitles the Maya to be regarded as civilized and, like the Peruvians, they carried it into many details of their civil and religious life. The correspondence between the symbols of their zodiac and our own must be apparent to the reader through practicaily all the signs. No one can explain that correspondence with certainty as yet. The many theories of pre-Columbian communication between America and the eastern continent have run the gamut from almost complete absurdity to moderate plausibility but none have established scientific conviction. Some anthropologists still insist that all such correspondences are unquestionably due to like independent causes producing like effects in like materia, the mind of man. The writer believes that the American zodiac as it existed in Peru, Yucatan, Mexico and among the Pueblo tribes of our own country affords at least as strong evidence of prehistoric communication between America and the eastern continent as has yet been discovered. It fails to explain the non-transmission of wheat and maize if we suppose a general migration but these objections are not valid against accidental and sporadic communication through shipwrecks.

Finally it may be hoped that the revealing of the Maya astronomical system may assist in unveiling the meaning of the great body of Maya glyphs which still remain an enigma for us.

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Various editions of the three Maya codices Peresianus, TroCortesianus (Madrid) and Dresden may be found in our larger libraries. A new edition of the Dresden is in course of publication by Mr. William Gates.

FIRST STUDY OF HEAVENLY BODIES.

By MARY E. BYRD.

Lesson VIII.

Far back in the distant past when our ancestors of the jungle were human enough to have thumbs, and look up with seeing eyes, the moon must have been the first object in the heavens to attract their attention at night. A knowledge of its motion among the stars antedates all folklore. In the ancient poem of Job we read of the moon "walking in brightness," and probably centuries before that was written, the Chinese had established the mansions of the moon near the "yellow

road" of the sun. Perhaps earlier still, doubtless some four thousand years ago, the Hindu astronomers had laid out their lunar zodiac.

We can hardly help a feeling of kinship with these ancient peoples. They too studied the heavens with their own eyes. The constellations which we call Pisces, Aries, Taurus, Leo, and Scorpio, just as we know them, were part of their zodiacs, and their star-gazers, two thousand years before the beginning of our era, were tracking the moon through the same path where we find it to-night.

It is, then, an old theme that we are to consider, the path of the moon through the constellations. During the past year it has been pretty well determined by students of these lessons. The hope expressed more than once for a series of observations extending through a complete circuit of the heavens has been realized by L. E. B., now of Washington, D. C. In June and July last, he was fortunate enough to fix the moon in reference to neighboring stars on 13 nights out of 23, and those who have kept the last watch of the night will realize the effort required to secure the four locations, made at 3 o'clock in the morning. The moon was actually "spotted" in eight of the zodiacal constellations. Points being fixed as follows: One in Cancer, three in Virgo, one in Libra, two in Scorpio, one in Sagittarius, two in Aquarius, two in Pisces, and one in Aries.

In making reductions, plotting comes first, that is, the places described in the notes, by careful measures and alignments are transferred to star-maps and the celestial globe (Lesson III, Byrd's First Observations, §§ 39, 51). The work is a bit tedious and in connection with it I am sometimes reminded of the student, who frankly told me, frankness was always encouraged, "I wish to drop astronomy and take some other study, one can get along so much faster reading books." Of course, it is a question where one wants to get along to. Not a few of us though we have crossed only the threshold of the portico of the temple of science prefer the slow ways, indicated by the old story of Agassiz, the student and the fish.

Even in the elementary problem considered here, it is a satisfaction to see the moon's path take shape under our fingers, stretching out from point to point till a complete circle is traced. To represent it graphically a strip of tracing cloth about a sixteenth of an inch wide is laid on the globe, so that while it responds, as one may say, to the pull of every point fixed, it passes through few of them, but a little above one and below another, marking out a smooth curve, not a zigzag line. With bits of paper pasted over the strip, to hold it in place, it can be examined at leisure, and a number of features are evident at once by mere inspection.

The direction of the path is unvaryingly eastward, with none of the backward or westward turns that mark the course of planets. It keeps always close to the ecliptic, and though it deviates 6° to the north and 7° to the south, instead of the 5° on either side, as given by the star-

dard authorities, that is hardly a bad "out" for a single path laid down without instrumental or optical help. And it must be granted as something of a triumph for the unaided eye that the path proves to be a closed curve, lying very nearly half above and half below the ecliptic, in other words coinciding closely with a great circle. It is seen also that the ascending and descending nodes, points where the lunar path crosses the ecliptic passing to the north and south, are separated, as they should be, by about 12 hours and are correctly located in Libra and Aries, though the degrees of longitude for the nodes read from the globe and taken from the *Ephemeris* are not in exact agreement.

Regarding these nodes there is an interesting question that must not be omitted. Do they remain fixed from month to month and year to year, or do they move forward or backward? Here the 14-day path for the moon in November and December, 1919, is helpful, and reference to that and to the later one just plotted shows that for both the descending node is located in the constellation Aries. Exact positions are difficult to fix owing to the small angle of inclination, but the evidence appears conclusive that in July the node is west of the winter position, that is, its motion is retrograde. In order to obtain, if possible, a numerical value for the rate at which it is moving, let us refer to a path like that of this year, determined by J. T. V. July, 1908 (Byrd's First Observations, §57). Its descending node, according to the original notes, was placed approximately in longitude 294°, and as the same node is found nearly in longitude 39°, in July, 1920, it has evidently retrograded 255° in 12 years, or 21° annually, a value too large by 2°, not an unreasonable error perhaps, considering the difficulties involved.

More nearly within reach of direct-eye observation is the problem of finding how rapidly the moon travels along its path, and for this there are abundant data. Any two positions give one value for the rate and with the thirteen there may be a large number of combinations. In making the choice there is no other than the usual limitation, the treatment must be perfectly fair, no favorites picked. So before there is any bias in behalf of particular positions, based on some inkling of how results will work out, let us decide on the five pair located in June, in which each two are separated by just 24 hours. The first dates are the 22nd and 23rd, and the distance between the position dots marked on the globe gives at once the daily rate in linear measure. To reduce it to degrees, note that on the part of the globe used, an hour-space or 15° equals 47.7 divisions on the plotting paper, but the distance between the dots is 43.7 divisions. We have, then, 43.7/47.7 of 15°, or a rate of 13°.7. The other four values are 15°.0, 10°.4, 13°.4, 13°.1, making the mean 13°.12, or 13°.1; as hundredths are retained merely to find tenths, for unaided-eye observing does not usually give ground for claiming to know the hundredth of a degree.

In all probability the large variations from the mean in the second

and third determinations are due largely to the globe itself. Every place fixed for the moon depends implicitly upon the places of the stars on the globe, and there seem to be special difficulties in locating them there as accurately as on star-maps. Thus, the five rates derived from plotting the same observations on Young's maps are 13°.6, 12°.6, 13°.4, 12°.9, 13°.7, giving a mean of 13°.2. It is of interest to see that the text book value, 13° 11′, lies between these two means (Young's Elements, Art. 141).

Data are now at hand for finding the length of the sidereal month, that is, the time it takes the moon to make the circuit of the heavens from star to star again. For if it travels 13°.1 a day, the time required to complete its course in a great circle is 360 divided by 13.1, or 27.48 days. In obtaining other and independent values for this month, we are fortunate in having supplementary observations, made last spring and summer by W. V. C. and A. L. P. First, let us take the position fixed by the latter on the night of the lunar eclipse, May 2, when the dark body of the moon was observed midway between α Librae and λ Virginis. Now it is seen that L. E. B.'s position for June 22 lies a little, 4°.15, west of this point, and so the moon requires, not only the interval between May 2 and June 22 to reach the initial position of May, but an additional fraction of a day, 0.32, to cover the intervening space. This whole interval, account being taken of the exact hours of observing, is 54.36 days. During this time, however, as the month is known to be only about 27 days long, there must have been two complete revolutions, with a period of 27.18 days for each.

Two positions by the same observers, and two by L. E. B. and W. V. C. give months of 27.27 and 26.93 days. Regarding the final positions to be considered there is something rather remarkable. A. L. P. and W. V. C. observed, one in December and one in May, one in Wisconsin, the other in Arkansas, and both located the moon on the prolongation of the same star line, $\delta\ \theta$ Leonis. It is then not surprising that the length derived for the sidereal month 27.30 days agrees closely with Young's value, 27.32 days (Young's Elements, Art. 141). But there is a fly in the ointment, a shadow of doubt whether the December observation was made on the 13th or 14th, though evidence for the latter, the one employed, is certainly strong. Taking the five periods just as given above, we obtain for the mean value of the sidereal month, 27.23 days, but if the earlier December date is used, this result is affected only by a few hundredths.

There is one other question on lunar motion that should receive brief attention. Does the moon in different months travel the same path through the zodiac? Let us amplify our globe plot by adding the five supplementary positions mentioned, the six obtained for the partial lunar path of 1919, and the fifteen, located for J. T. V.'s path, a dozen years ago. An examination of all these points shows that the observations are best satisfied by assuming that the moon moves in paths that veer a little north and south; and yet results are so masked by errors

in observing and in the globe that it is impossible to affirm with certainty whether or not the moon at the beginning of each month returns to the same starting point and passes over and over the same course (Young's Elements, Art. 142). The one fact that does stand out clearly is this, paths and sections of paths, whenever described, all lie near together, in the zodiac.

The subject of the moon is a difficult one to put aside, it is so old, so new, so rich in challenges to investigation. But there are other celestial bodies and other problems. One about the stars was suggested a year ago by a New York correspondent, who queried "Could one, at some hour of the night, identify an aspect of the stars as belonging to the 9 o'clock position by saying, I am looking at an April sky, for example, at 11 o'clock in March?"

The following observations made by students at Smith College Observatory leave no room to doubt that the same aspect of the stars recurs at regular intervals:

S. C. O., Northampton, Mass., Monday, November 29, 1920.

POSITION OF CONSTELLATIONS.

"From a large level stone, known as meridan stone G. I noted the stars and constellations seen between 9^h and $9^h\ 20^m$. Those conspicuous in the north were Ursa Major, Ursa Minor and Draco; in the east, Orion, Auriga and Taurus; in the west, Lyra, Cygnus, Aquila and Delphinus; in the south, Cetus, Aquarius and Pisces; and in the zenith were Cassiopeia, Aries, Triangulum, Pegasus, Andromeda and Perseus.

"In the east Canis Minor was the constellation just visible above a house-roof which limits my horizon, β Can. Min. was one quarter the distance β Can. Min.—γ Gem. above this house. In the west, Delphinus was just above some trees. The distance α Delph.—ϵ Cygni was equal to the distance α Delph. above the horizon line as it would have appeared had it not been for the trees. Directly overhead in the zenith was γ And., above the pole star, toward the zenith, on the meridian was ι Cass., and below the pole star was 4 Urs. Min., a rather faint star to the right of β. Horizontally to the left of Polaris was η Ceph. and to the right was H 25 Camelop. Along the meridian in the south were α Pisc., α Ariet., and β Trian.

"While identifying these constellations, I found that in the zenith a line through κ and ϵ Cass. pointed almost due east and west. In the north the other stars of Urs. Min. were below Polaris and β was a little to the left of a plumb line dropped from the pole star. In the northwest Lyra was just above a house which limited my horizon and the line through α and ζ was almost horizontal. In the east the line ϵ—θ Aurigae was almost vertical; and in the south, well up from the horizon, the line α—γ Ceti was nearly horizontal." —E. M.

S. C. O., Northampton, Mass., Tuesday, December 28, 1920.

POSITION OF CONSTELLATIONS.

"My purpose in making this observation is to see how the position of the constellations tonight corresponds with that described by E. M., November 29, between 9^h and $9^h\ 20^m$. I begin observing at $7^h\ 10^m$ and end at $7^h\ 50^m$.

"The chief constellations in the north, south, east, west and zenith correspond to those in E. M.'s list, except that I should call Aquarius west rather than south. Procyon (α Can. Min.) could be seen above the house-roof in the east, and β Can. Min. was above the roof, a third of the distance between β and γ Gem. and therefore a little higher than when observed in November. Delphinus was so involved in the branches of two trees that I could not see the configuration clearly.

"Near the zenith was γ And. and it was the only bright star near it, ι Cass. was on the meridian, toward the zenith and above the pole, η Cephei was distinctly above a horizontal line, to the left of the pole star and H 25 Camelop. was distinctly below, at the time I observed which was about $7^h\ 40^m$. In the south a nearly straight line would pass through υ Ceti, α Pisc., α Ariet., and β Trian., but slightly to the west of the meridian. From an observation made at $8^h\ 15^m$, I should judge that these stars would have been on the meridian at about $7^h\ 20^m$.

"By $7^h\ 40^m$, β Urs. Min. was in a plumb line dropped from Polaris, Lyra was no longer visible though I had seen it earlier, the line ϵ—θ Aurigae appeared nearly vertical and the line α—γ Ceti almost horizontal.

"In comparing these positions of stars and constellations, December 28, with those noted November 29, four weeks and one day earlier, I should judge that observations made tonight between 7^h and $7^h\ 30^m$ would have corresponded with those of November much more exactly than those actually made between $7^h\ 15^m$ and $7^h\ 45^m$." —C. E. H.

To A. L., another Smith College student, acknowledgment should be made for observations, similar to those above.

The days are growing longer and winter wears away but Taurus and Orion still grace our evening skies, the brightest star shines in the east and the brightest planet in the west, yet February so often brings clouds and bitter cold that it is one of the least favorable months for direct study of the heavens. Even love for the stars does little to mollify zero temperatures and it is an ill omen for observing when the personal equation freezes up! It is a time of year especially appropriate for the study of books and maps, for plotting and reducing observations, and for carrying out discussions like that of lunar motions, given in the body of the lesson. Let us turn, then, to topics like the following:

TOPICS FOR LESSON VIII.

1. Read myths and legends of the moon by popular authors and study Chapter V in Young's Elements.
2. What is meant by precession and how does it affect star places on maps and globe?
3. Explain how to find approximately the epoch for which a particular celestial globe was constructed, and thus verify the maker's date or supply its omission.
4. Give the times of year especially favorable for using the solar-image gnomon, with conclusions based both on theory and your own experience.
5. Referring to the observing note-book, write out an account of observations made of the moon, showing what you have learned at first hand.
6. Collect from this note-book all determinations of some unknown quantity, for example, latitude, explaining briefly how the individual values were obtained, and noting their variations from the mean.
7. How could the sidereal period of the moon be found roughly by observing its conjunctions with Jupiter or Saturn? Why would other planets not be suitable for this purpose?
8. Having taken from the *Ephemeris* the longitude of the moon's ascending node January 1 and June 1, 1921, ascertain approximately how far it moves backward on the ecliptic during the half year.
9. Find from the common almanac when Venus is next in inferior conjunction, and then independently of the almanac, by reference to Young's Elements, determine the two dates on which maximum brightness comes this spring.
10. Explain why it is that the aspect of the stars varies so largely at the same hour in different months and in different seasons.

It occurs to me to remark that there is no law against star-gazing in February.

Route 9, Box 77, Lawrence, Kansas.

TWENTY-FIFTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

The twenty-fifth meeting of the Society was held in affiliation with the American Association for the Advancement of Science at the University of Chicago on December 28-30, 1920. This was the second of the large gatherings of the Association which meet in rotation at one of the centers, New York, Chicago, and Washington, when a special effort is made to get as many as possible of the affiliated societies

together. The Society has adopted the policy of meeting at these times, the last such occasion being at New York in 1916.

The sessions of the Society were held in the Ryerson Physical Laboratory, and the members had opportunity to intermingle with workers in other fields, and to benefit from the various features of the general program. In spite of the present cost of travel this was the largest meeting in point of attendance which has ever been held by the Association, and the representation of the Society was well up to the average at summer meetings, about sixty members being present. The members roomed at various places about the city, most of them being at the Great Northern Hotel, which was also the headquarters of the mathematicians.

As usual there was no dearth of astronomical papers, though it was possible to get through the regular program without too much haste. In the absence of the president and both vice-presidents of the Society, none of whom were able to be present, the successive sessions were presided over by Messrs. Miller, Comstock, Stebbins, and Frost. On Tuesday, the first day, there were morning and afternoon sessions for papers, but on Wednesday morning the Society adjourned to attend a joint session of the American Physical Society and the Optical Society of America. It was at this combined meeting that the most important astronomical paper was read, in fact it was the striking event of the entire week, the announcement by Professor Michelson of the successful measurement of the apparent diameter of a star by his interferometer method applied at Mount Wilson. (See paper by F. G. Pease in abstracts following this report.) It was significant that this achievement had been accomplished only a few days before the Society came to the Ryerson Laboratory.

In accordance with the policy of the Association there was no formal program of Section D-Astronomy, and the astronomical papers were continued on Wednesday afternoon. On the same evening there was a joint dinner of mathematicians and astronomers at the Quadrangle Club, where we renewed acquaintances formed at Ann Arbor in 1919. The session on Thursday morning continued until every one present had had his chance to give a paper, and the meeting was then adjourned.

As this was not the annual meeting of the Society, there were relatively few matters of business, such as the election of officers, to come up. New members were elected as follows:

Ida Barney, Smith College, Northampton, Mass.
Charles E. Barns, Morgan Hill, Cal.
Charles C. Godfrey, 340 State Street, Bridgeport, Conn.
Julian Lowell Coolidge, Harvard University, Cambridge, Mass.
Laura E. Hill, Dearborn Observatory, Evanston, Ill.
Milton L. Humason, Mount Wilson Observatory, Pasadena, Cal.
Alfred H. Joy, Mount Wilson Observatory, Pasadena, Cal.
Glenn A. Shook, Box 4, Wheaton College, Norton, Mass.
Charles Campbell Smith, Dominion Observatory, Ottawa, Canada.

Gustaf Benjamin Strömberg, Mount Wilson Observatory, Pasadena, Cal.
George C. Waldo, Jr., 55 Grovers Ave., Bridgeport, Conn.

The following members were in attendance at the Chicago meeting:

Sebastian Albrecht	H. G. Gale	H. H. Plaskett
R. H. Baker	E. S. Haynes	H. M. Randall
E. E. Barnard	C. S. Howe	W. F. Rigge
S. B. Barrett	W. J. Humphreys	F. E. Ross
L. A. Bauer	Mrs. A. H. Joy	W. C. Rufus
Harriet W. Bigelow	A. H. Joy	R. E. Schmidt
Dorothy W. Block	Kurt Laves	L. Silberstein
F. E. Brasch	O. J. Lee	Frederick Slocum
C. A. Chant	A. O. Leuschner	C. C. Smith
W. A. Cogshall	A. C. Lunn	Joel Stebbins
G. C. Comstock	W. D. McMillan	R. M. Stewart
Henry Crew	E. S. Manson, Jr.	G. D. Swezey
C. C. Crump	C. E. K. Mees	F. D. Urie
R. H. Curtiss	A. A. Michelson	Georges Van Biesbroeck
Louis Derr	D. C. Miller	S. J. A. Wifvat
A. E. Douglass	J. A. Miller	D. T. Wilson
H. O. Eaton	S. A. Mitchell	C. C. Wylie
E. A. Fath	D. W. Morehouse	L. R. Wylie
Philip Fox	E. J. Moulton	Anne S. Young
E. B. Frost	F. R. Moulton	Jessica M. Young

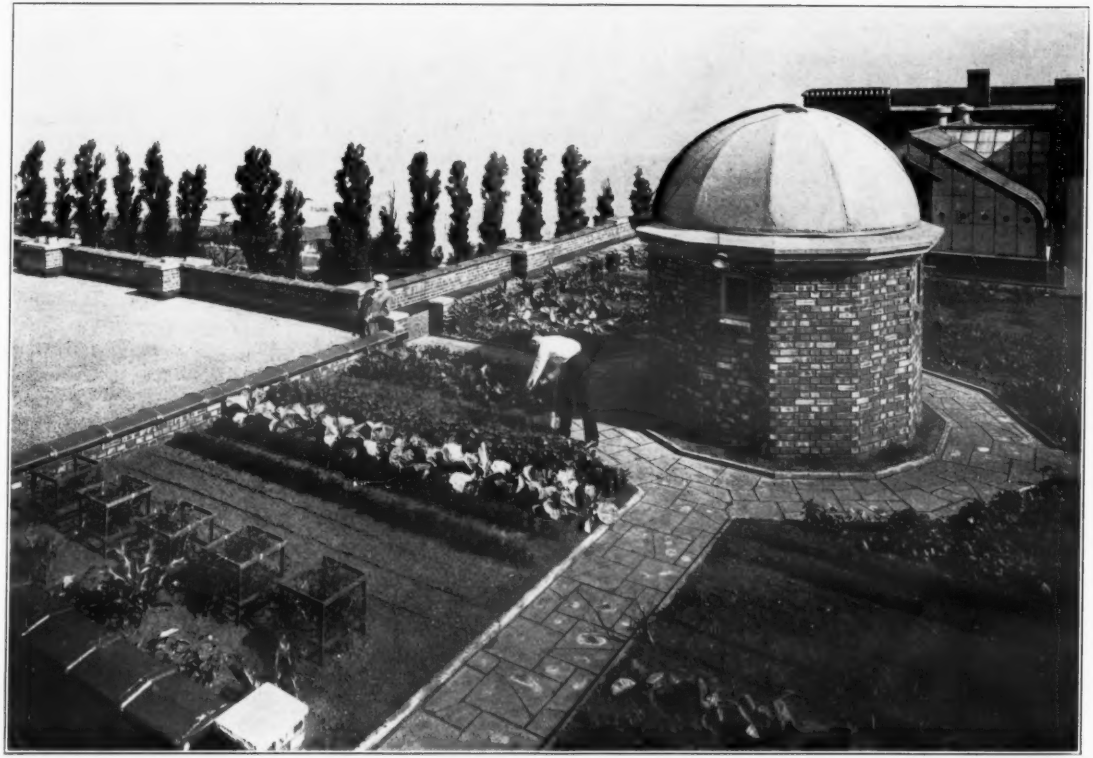
The summer meeting of 1921 will be held in the eastern part of the country.

AN ASTRONOMICAL OBSERVATORY ON A FACTORY ROOF.

One of the most unique observatories in the world, unique at least as regards its location, is the one which is mounted on the roof of the new four-story factory of The Globe Machine & Stamping Company of Cleveland, Ohio. It was designed, built and equipped by Albert F. Schroeder, the General Manager of the Company, on the roof of his factory and surrounded by features as novel and unusual as the observatory itself. These other features of the Globe roof include a kitchen-vegetable garden, a greenhouse, a Spanish Bungalow, a formal garden, a sun-dial and a fountain, as well as an open-air moving picture theatre for the Globe employes.

In the year 1880, Mr. Schroeder, then a lad of thirteen, who previously since the age of nine had been reading most of the standard works in the line of astronomy and geology, saw in an issue of The Youth's Companion, an article captioned "How to make a Telescope." And so young Schroeder was inspired to make his first telescope. He got a curtain pole about forty inches long and two inches in diameter, and wound it with heavy packing paper to a thickness of about a quar-

PLATE VII



ASTRONOMICAL OBSERVATORY ON THE ROOF OF THE FACTORY OF THE GLOBE MACHINE AND STAMPING COMPANY, CLEVELAND.
POPULAR ASTRONOMY, No. 282.

ter of an inch, liberally brushing glue between the laminations, and this when dry and removed from the core, namely the curtain pole, resulted in a substantial tube, well suited for his purpose. The double-convex objective of two inches diameter and forty-two inches focus was mounted in a brass fitting which was attached to one end of the paper tube, while a wood bushing glued into the other end of the tube, supplied means for the insertion of the small brass tube in which two small plano-convex lenses mounted in card-board discs or washers provided for the eye-piece. The completed instrument had a power of about forty diameters, and was mounted on a wood-tripod, which had ingenious adjusting rods extending to the eye-piece end, in order to prevent excessive vibration. By means of thumb-nuts, operated during observation, the moon or other heavenly body, could be followed quite satisfactorily.

This crude instrument served to stimulate the boy's interest in amateur astronomy. His interest in astronomy, however, did not interfere with the work of building up a business, and in 1912, upon the completion of the first concrete building by The Globe Machine & Stamping Co., Mr. Schroeder secured a far more pretentious instrument than the one of his boyhood days, namely an Alvan Clark Telescope with a 5½-inch objective and with powers ranging from 50 diameters to 400 diameters. This instrument was mounted equatorially, on the roof of the Globe's two story building, on a concrete pedestal weighing about 2000 pounds.

In 1918, when the new four story building was completed, Mr. Schroeder built the observatory which is shown in the illustration and added the greenhouse and garden features mentioned above; and the telescope was then moved to the new, high roof. In its new location, the telescope is mounted on a concrete pedestal weighing 2000 pounds, which in turn rests on a solid concrete roof and directly over a line of concrete piers which support the roof and extend down to the foundation of the building, about eighty feet below.

The wall of the Observatory is nine-inch brick, and its weight serves to stablize the entire structure, thus eliminating vibration. The floor of the observatory is of wood, but is so framed around the telescope's pedestal as to be free from contact with the latter so no tremors of the floor will be communicated to the pedestal. The revolving dome of the observatory was made by Globe factory mechanics, out of 16 guage steel, covered with a very thick rubberoid roofing material, which was cemented to the steel dome with a compound which only becomes fluid at 180 degrees. The observing-slit in the dome is covered by a heavy canvas cover, which is stiffened every four inches by a piece of spring-brass about one inch wide and of 16 guage firmly sewed between the two layers of canvas which form the cover. The cover or curtain rolls up at will on a piece of two-inch steel shafting, operated by cords from the inside. The steel dome is attached to a wooden plate or sill

which in turn rolls on a set of eight iron rollers or wheels, same being about six inches in diameter, these rollers being in turn bolted on to another wood plate or sill which in turn is firmly bedded into the top of the brick wall. The rotating is done by means of a lever, fulcrumed on to the brick wall, and its upper end acting on or engaging in a series of iron lugs, spaced about six inches apart, around the under surface of the rotating wood sill on which the steel dome is mounted. By means of this device the dome can be rotated in either direction. An electric heater supplies moderate warmth in the event of extremely cold weather.

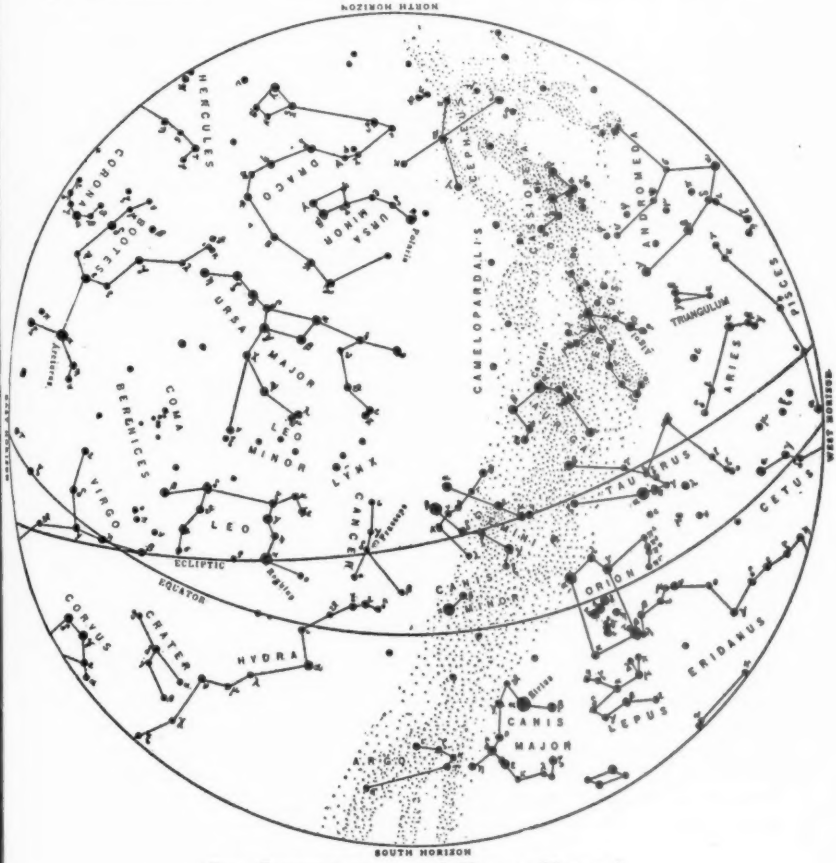
The illustration (Plate VII) shows a portion of the roof of the four story building, which is L shaped, each leg of the L being about 220 feet by 60 feet. The observatory is shown occupying the center of the kitchen garden back of the greenhouse. The formal garden in front of the bungalow is about the same size and of similar arrangement to the kitchen garden except that a sun-dial occupies the flagged center. The formal garden is adorned with a great variety of hard ever-greens, fir, spruce, also a variety of roses and flowering shrubs. The pond in connection with the fountain contains numerous gold-fish. The upper floor of the building is devoted to a luxurious assembly hall, a library, bowling alleys, bath rooms and other comforts which are enjoyed by such employees as join the Globe Social Club. Underneath all this is a busy factory.

Mr. Schroeder is not an educated man in the ordinary acceptance of the term. In fact, he commenced to work at the early age of thirteen, because of the poverty of the family of which he was a member. After working about twenty years with two other concerns, he started the Globe, which he built up from a very modest beginning into what is one of the foremost plants in the city of Cleveland. He was an inveterate reader of entertaining and instructive literature, his favorite author being Charles Dickens. He is a firm believer in being on friendly and companionable terms with his employees, and is a good mixer among his employees and their families at the occasional social functions given by the Globe Social Club in the factory club rooms.

The library in the club contains about forty books on astronomical subjects, in which the employees are encouraged to interest themselves, and those who take advantage of this opportunity are accorded the use of the observatory.

PLANET NOTES FOR MARCH, 1921.

The *Sun* enters Aries on March 20 at 9^h 51^m P. M. C. S. T. at which time spring commences.



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

The phases of the *moon* for this month are as follows:

New Moon	March	9	at 12: 9.2	P.M.	C.S.T.
First Quarter		16	" 9:49.2	"	"
Full Moon		23	" 2:18.9	"	"
Last Quarter		31	" 3:13.4	A.M.	"

Mercury will be at inferior conjunction with the sun on the 2nd; on the 15th the planet will be stationary; on the 21st at its descending node; on the 30th at greatest western elongation and in aphelion on the 31st. On account of the

elongation occurring so near aphelion passage the distance from the sun will amount to 27° 50′ which is very near the maximum value. The planet should be plainly visible to the naked eye at an altitude of nearly 12° above the eastern horizon about an hour before sunrise at the time of elongation as well as several days before and after this event.

Venus will be in perihelion on the 3rd; at greatest brilliancy with a stellar magnitude of —4.3 on the 17th; at greatest heliocentric latitude north on the 24th and stationary on the 31st. In the telescope the planet will appear as a crescent.

Mars and *Uranus* will be too near the sun for observation.

Jupiter will be at opposition on the 4th and thus in a good position for observation after 9 P. M. On another page will be found the satellite phenomena for the month.

Saturn will be at opposition on the 12th. The rings should be readily visible as a line of light in a small telescope by the first of the month as the earth will have passed through the plane of the rings a week before.

Neptune's position on the 15th will be $\alpha = 8^h\ 55^m\ 14^s$, $\delta = +17°\ 26'$. Anyone possessing a small telescope and a star chart may find Neptune as an 8th magnitude star in this part of the sky. A power of 100 or more will show the disk of the planet.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1921	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle E from N	EMERSION. Washington M.T.	EMERSION. Angle E from N	Duration
			h m	°	h m	°	h m
Mar. 14	33 B Tauri	6.3	5 16	113	6 25	228	1 9
17	26 Gemin.	5.2	8 59	109	10 12	276	1 12
19	A^2 Cancri	5.7	12 6	82	13 2	321	0 56

Venus, Mars, and Uranus.

The close approach of the three planets, Venus, Mars, and Uranus, on January 8 was observed under moderately favorable conditions at Northfield. The sky was very clear but the air extremely unsteady. The three planets were visible at the same time in the field of the 5-inch finder of the 16-inch equatorial. The strong color contrasts of the three planets were very marked, the glistening white of Venus, the reddish tints of Mars and the faint green of Uranus being enhanced by the presence of the others. We hope many others had as good a view as was obtained here as it was a sight which will be long remembered.

Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.
[From the *American Ephemeris.*]
CENTRAL STANDARD TIME.

1921	d	h	m				d	h	m		
Mar.	1	5	59	III	Sh. E.	Mar.	4	14	52	I	Tr. I.
		6	12	III	Tr. E.			14	52	I	Sh. I.
	2	6	40	II	Ec. D.			16	34	III	Ec. D.
		9	36	II	Oc. R.		5	11	59	I	Oc. D.

1921	d	h	m				d	h	m		
Mar.	5	14	17	I	Ec. R.	Mar.	16	14	43	II	Ec. R.
	6	9	18	I	Tr. I		18	6	2	II	Sh. I.
		9	21	I	Sh. I.			8	11	II	Tr. E.
		11	34	I	Tr. E.			8	52	II	Sh. E.
		11	37	I	Sh. E.		19	8	30	IV	Tr. I.
	7	6	25	I	Oc. D.			11	45	IV	Sh. I.
		8	45	I	Ec. R.			12	3	IV	Tr. E.
		14	1	II	Tr. I.			15	27	I	Oc. D.
		14	10	II	Sh. I.			15	36	IV	Sh. E.
		16	49	II	Tr. E.		20	12	47	I	Tr. I.
		16	59	II	Sh. E.			13	10	I	Sh. I.
	8	6	0	I	Tr. E.			15	2	I	Tr. E.
		6	6	I	Sh. E.			15	26	I	Sh. E.
	8	6	21	III	Tr. I.		21	9	53	I	Oc. D.
		6	41	III	Sh. I.			12	34	I	Ec. R.
		9	29	III	Tr. E.		22	7	13	I	Tr. I.
		9	57	III	Sh. E.			7	38	I	Sh. I.
	9	9	2	II	Oc. D.		22	9	28	I	Tr. E.
		12	7	II	Ec. R.			9	54	I	Sh. E.
	11	5	56	II	Tr. E.			12	56	III	Tr. I.
		6	17	II	Sh. E.			14	39	III	Sh. I.
		8	4	IV	Ec. R.		23	6	2	I	Ec. R.
		16	36	I	Tr. I.			13	33	II	Oc. D.
		16	47	I	Sh. I.		25	7	38	II	Tr. I.
	12	13	43	I	Oc. D.			8	37	II	Sh. I.
		16	11	I	Ec. R.			10	26	II	Tr. E.
	13	11	2	I	Tr. I.			11	27	II	Sh. E.
		11	15	I	Sh. I.			7	44	III	Ec. R.
		13	18	I	Tr. E.			6	36	II	Ec. R.
		13	32	I	Sh. E.			14	32	I	Tr. I.
	14	8	9	I	Oc. D.			15	4	I	Sh. I.
		10	39	I	Ec. R.		28	11	38	I	Oc. D.
		16	15	II	Tr. I.			14	28	I	Ec. R.
	15	5	44	I	Sh. I.		29	8	58	I	Tr. I.
		7	44	I	Tr. E.			9	33	I	Sh. I.
		8	0	I	Sh. E.			11	14	I	Tr. E.
		9	38	III	Tr. I.			11	49	I	Sh. E.
		10	40	III	Sh. I.		30	6	4	I	Oc. D.
		12	46	III	Tr. E.			8	57	I	Ec. R.
		13	55	III	Sh. E.		31	6	17	I	Sh. E.
	16	11	17	II	Oc. D.						

NOTE:—I. denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Saturn's Satellites.

Greatest elongations visible in the United States.
[From the *American Ephemeris.*]
CENTRAL STANDARD TIME.
I. Mimas. Period $0^d\ 22^h.6$.

1921	d	h		d	h		d	h		d	h	
Mar.	1	7.9	W	Mar. 9	8.1	E	Mar. 17	8.4	W	Mar. 24	10.0	E
	1	19.2	E	9	19.4	W	17	19.6	E	25	8.6	E
	2	6.5	W	10	6.7	E	18	7.0	W	26	7.2	E
	2	17.8	E	10	18.0	W	18	18.3	E	26	18.5	W
	3	16.4	E	11	16.6	W	19	5.6	W	27	5.8	E
	4	15.0	E	12	15.3	W	19	16.9	E	27	17.1	W
	5	13.7	E	13	13.9	W	20	15.5	E	28	15.7	W
	6	12.3	E	14	12.5	W	21	14.1	E	29	14.3	W
	7	10.9	E	15	11.1	W	22	12.7	E	30	13.0	W
	8	19.5	E	16	9.7	W	23	11.3	E	31	11.6	W

II. Enceladus. Period 1d 8h.9.

1921	d	h		d	h		d	h		d	h	
Mar.	1	20.5	E	Mar. 10	1.8	E	Mar. 18	17.0	E	Mar. 26	12.3	E
	3	5.4	E	11	10.6	E	19	15.9	E	27	21.2	E
	4	14.2	E	12	19.5	E	21	0.8	E	29	6.0	E
	5	23.1	E	14	4.4	E	22	9.6	E	30	14.9	E
	7	8.0	E	15	13.3	E	23	18.5	E			
	8	16.9	E	16	22.1	E	25	3.4	E			

III. Tethys. Period 1d 21h.3.

Mar.	0	21.0	E	Mar. 8	12.1	E	Mar. 15	23.3	E	Mar. 23	12.5	E
	2	18.3	E	10	7.4	E	17	20.6	E	25	9.8	E
	4	15.6	E	12	4.7	E	19	17.9	E	27	7.0	E
	6	12.8	E	14	2.0	E	21	15.2	E	29	4.4	E
										31	1.6	E

IV. Dione. Period 2d 17h.7.

Mar.	3	6.0	E	Mar. 11	17.9	E	Mar. 19	12.9	E	Mar. 27	17.9	E
	5	20.6	E	14	1.6	E	22	6.6	E	30	11.5	E
	8	14.3	E	16	19.2	E	25	0.2	E			

V. Rhea. Period 4d 12h.5.

Mar.	2	6.4	E	Mar. 11	7.1	E	Mar. 20	7.7	E	Mar. 29	8.4	E
	6	18.8	E	15	19.4	E	24	21.1	E			

VI. Titan. Period 15d 23h.3.

Mar.	4	0.1	E	Mar. 11	19.4	W	Mar. 19	21.7	E	Mar. 27	16.8	W

VII. Hyperion. Period 21d 7h.6.

Mar.	8	21.5	W	Mar. 20	18.1	E	Mar. 30	3.6	W			

VIII. Iapetus. Period 79d 22h.1.

				Mar. 9	5.4	E	Mar. 28	3.4	I			

IX. Phoebe. Period 523d 15h.6.

	α Ph.	—α Sat.	δ Ph.	—δ Sat.		α Ph.	—α Sat.	δ Ph.	—δ Sat.
Mar.	2	+0 13.9	—3	4	Mar. 18	+0	36.4	—5	40
	4	0 16.7	3	24	20	0	39.1	5	59
	6	0 19.6	3	44	22	0	41.9	6	17
	8	0 22.4	4	4	24	0	44.6	6	34
	10	0 25.3	4	23	26	0	47.2	6	52
	12	0 28.1	4	43	28	0	49.7	7	9
	14	0 30.9	5	2	30	+0	52.3	—7	22
	16	+0 33.7	—5	21					

NOTE:—E, Eastern Elongation; I, Inferior Conjunction (south of planet); W, Western Elongation; S, Superior Conjunction (north of planet).

Taurus's Startling Position.

One night when the sky with stars was full,
I looked for the constellation, The Bull.
For I knew well that when spread out before us
No stars are finer than those in Taurus.

A country man was strolling by,
And me, through the dark, could just descry.
He thought I was hunting some cat in a tree,
So he offered to keep me company.

"For hunting," said he, "the light is too dull."
"It's all right," I said, "I'm finding the Bull
With the Golden Horn and the Bright Red Eye——"
Through the dark I could hear him begin to fly.
Dropping his hat and his walking stick,
To escape from the reach of a lunatic!

—Duncan Saunders.

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1921 March					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	4 11					
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	3 21	11 13	19 5	26 21		
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	6 15	14 1	21 11	28 22		
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	6 9	13 20	21 8	28 19		
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	3 6	9 9	21 14	27 17		
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	5 11	12 5	19 18	26 22		
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 13	11 10	18 7	25 3		
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	1 19	8 23	23 7	30 11		
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	8 14	17 9	26 3			
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 3	13 2	21 1	28 23		
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6				29 13		
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2 19	8 12	19 23	25 17		
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6 5	13 0	19 19	26 14		
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	6 23	14 21	22 18	30 16		
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	1 1	9 9	17 16	26 0		
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	1 5	8 3	17 0	24 22		
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	1 7	14 11	27 16			
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	1 22	11 9	20 19	30 6		
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	5 8	17 18	30 4			
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	8 14	15 5	21 21	28 13		
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	4 23	13 4	21 9	29 13		
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	6 0	12 1	24 2	30 3		
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	8 2	16 18	25 10			
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9		11 21	22 7			
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	8 15	16 15	24 16			
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	3 19	9 12	20 23	26 17		
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	2 20	14 0	19 15	30 20		
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	3 1	11 6	19 10	27 15		
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	1 19	9 10	17 1	24 16		
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	6 16	18 21	31 2			
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	6 18	13 23	21 2	28 7		
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	8 16	15 11	22 7	29 2		
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	9 14	18 21	28 4			
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	3 4	9 19	23 0	29 15		
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	5 20	14 5	22 15	31 0		
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	1 21	8 8	21 4	27 15		
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	2 18	10 0	24 13	31 20		
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	2 3	10 6	18 9	26 11		
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	9 6	18 18	28 5			
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 6.8	5 1	13 21	20 18	27 14		
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	2 15	9 13	21 10	27 8		
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6 6	13 0	19 18	26 12		
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	5 2	12 12	19 22	27 8		
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	6 16	13 7	19 21	26 12		
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	3 5	12 0	20 20	29 15		
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	5 2	12 10	19 18	27 2		
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3 18	10 12	24 2	30 21		
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	3 16	11 4	18 16	26 4		
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	4 15	14 5	23 19			
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	1 20	8 6	24 3	31 14		
133926 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	4 21	10 16	22 6	28 1		

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1921 March							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
δ Libræ	14	55.6	— 8	07	4.8— 6.2	2	07.9	5	14	12	13	19	13	26	13
U Coronæ	15	14.1	+32	01	7.6— 8.7	3	10.9	5	20	12	18	19	16	26	13
TW Draconis	15	32.4	+64	14	7.3— 8.9	2	19.3	5	5	13	15	22	1	30	11
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	6	3	13	19	21	11	29	2
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	8	2	15	10	22	18	30	2
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	3	22	12	4	20	10	28	16
R Aræ		31.1	—56	48	6.8— 7.9	4	10.2	2	13	11	9	20	5	29	2
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	2	1	11	18	22	20		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	4	14	11	19	24	23	31	19
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	1	3	9	12	17	21	26	7
μ Herculis		13.6	+33	12	4.6— 5.4	2	01.2	6	3	12	6	24	14	30	17
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	4	7	10	11	22	20	27	0
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	2	3	9	12	24	6	31	15
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	8	11	16	16	24	20		
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	5	4	12	17	20	6	27	19
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	2	2	9	20	17	14	25	7
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	3	20	11	19	19	19	27	19
WX Sagittarii		53.6	—17	24	9.2—10.8	2	03.1	1	2	9	15	18	3	26	16
WY Sagittarii	17	54.9	—23	1	9.5—10.6	4	16.0	9	15	18	23	28	7		
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	7	16	18	1	28	9		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	4	8	11	14	18	20	26	2
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	3	22	10	20	24	16	31	13
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2	7	13			22	17		
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	5	0	12	4	19	8	26	12
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	6	3	13	5	20	8	27	11
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	9	13	17	21	26	4		
RR Draconis		40.8	+62	34	9.3—13	2	19.9	2	3	10	14	19	2	27	14
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	3	14	9	19	23	2	29	18
β Lyræ		46.4	+33	15	3.4— 4.1	12	21.8	5	10	18	7	31	5		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	9	13	17	5	24	20		
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	5	2	12	16	20	6	27	19
RV Lyræ		12.5	+32	15	11. —12.8	3	14.4	6	11	13	16	20	20	28	1
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	6	8	15	7	24	6		
U Sagittæ		14.4	+19	26	6.5— 9.0	3	09.1	6	18	13	12	20	5	27	1
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	2	1	9	9	24	2	31	11
TT Lyræ		24.3	+41	30	9.4—11.6	5	05.8	4	11	9	17	20	5	30	16
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	6	17	13	6	19	18	26	6
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	4	9	10	10	22	10	28	10
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	1	19	8	11	21	17	28	8
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	3	16	17	19	26	23		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	6	16	15	3	23	13		
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	1	18	8	13	22	3	28	22
UW Cygni		19.6	+42	55	10.5—13	3	10.8	5	11	12	9	19	7	26	4
V Vulpec.		32.3	+26	15	8.2— 9.8	37	19.0			11	3				
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	5	9	15	0	24	15		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	1	12	10	17	19	22	29	2
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	2	19	10	17	17	19	25	6
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	1	20	9	11	17	1	24	15
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	2	22	13	1	23	3		
VVCygni	21	02.3	+45	23	12.1—13.8	1	11.4	1	11	8	20	23	14	30	23
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	1	11	11	3	20	20	30	12
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	5	0	12	21	20	18	28	15
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5	01.7	3	3	13	6	23	10		
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3	6	20						
RW Lacertæ	22	40.6	+49	08	10.2—11.2	5	04.4	4	11	14	20	25	5	30	9
8.1914 Pegasi		51.7	+32	41	10.0—10.6	5	06.4	3	14	13	3	23	16	28	22
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.4	7	18	16	1	24	9		
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.3	1	3	8	16	23	18	31	7
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	10	12	18	18	27	0		

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1921 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7					26 17			
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	5 18	13 21	22 0	30 4				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	8 15	16 9	23 3	31 21				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		11 22		26 7				
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 3	10 2	18 0	25 23				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	7 5	14 1	22 19	30 14				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	3 17	10 23	18 6	25 13				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	4		20					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	4 8	12 22	19 12	30 2				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1		11 0	23 3					
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	7 19	19 10	31 1					
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	5 15	13 7	20 23	28 14				
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	11 0	21 3	31 6					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	4 14	12 7	20 1	27 17				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 11	9 23	21 1	26 13				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	5 1	12 14	20 4	27 17				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		12 13						
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	9 2	16 13	24 1	31 11				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	4 13	11 18	18 23	26 4				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	8 16	16 14	24 12					
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	5 3	15 6	25 10					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		15 9						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	9 18	17 17	25 16					
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	3 22	10 15	24 1	30 17				
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	2 17	11 23	21 6	30 12				
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	9 3	17 21	26 15					
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	8 3	14 22	21 17	28 12				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5 21	12 11	19 2	25 16				
S Muscæ	12 07.4	—69 36	6.4— 7.3	9 15.8	5 19	15 11	25 2					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	3 3	11 2	19 2	25 1				
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	1 4	7 21	21 8	28 2				
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	2 3	7 23	19 15	25 11				
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	2 4	11 13	20 22	30 7				
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5		11 0		28 7				
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8		9 0	17 5	25 10				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 0	13 0	20 1	27 1				
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	9 0	17 5	25 10					
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	6 12	12 0	17 12	28 11				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	6 10	13 23	21 12	29 2				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	2 3	9 13	24 8	31 18				
R Triang. Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	7 1	13 20	20 14	27 9				
S Triang. Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	1 6	7 13	20 5	26 13				
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	4 10	14 4	23 22					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	8 23	17 20	26 17					
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	6 8	12 10	24 13	30 14				
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	5 0	12 0	19 0	26 0				
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9	1 8		18 11					
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	5 22	13 12	21 2	28 16				
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	6 7	12 3	23 16	29 10				
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	3 4	9 22	23 10	30 4				
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	4 2	14 11	24 19					
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	2 17	8 18	20 19	26 20				
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	2 2	8 5	20 12	26 15				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1921 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	5 21	11 20	23 17	29 16				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	8 4	17 7	26 9					
U Aquilæ	19 24.0	− 7 15	6.2— 6.9	7 00.6	1 3	8 4	22 5	29 6				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	1 18	8 18	22 18	29 18				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	5 20	13 20	21 19	29 19				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	6 11	14 4	21 20	29 13				
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	8 3	15 7	22 12	29 16				
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	5 6	13 15	22 0	30 9				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	4 2	10 10	23 1	29 8				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	9 7		25 17					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	2 23	11 20	20 17	29 13				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	1 0	7 18	21 5	27 22				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	3 3	9 20	23 6	29 23				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	7 15		22 8					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	3 16	11 12	19 9	27 6				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	3 7	10 5	23 23	30 21				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	3 15	8 12	18 5	27 23				
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	5 8	14 0	22 15	31 7				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	7 15	13 0	23 18	29 2				
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1		13 4	24 1					
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	5 3	11 13	24 9	30 19				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	2 10	7 10	17 9	27 8				
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	6 21	12 8	23 5	28 16				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	5 4	10 14	21 12	26 22				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 4	11 12	24 2	30 9				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		9 6	21 10					
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	4 1	11 0	25 0	31 23				

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, November 20 to December 20, 1920.

Winter observing conditions have interfered with the work the past month, but the present report shows that the observers are making a stubborn effort to follow as many stars as possible. The McCormick Observatory found SS Aurigae nearly up to maximum on December 5, and a good many secured observations of it. Attention is called to the fact that R Coronæ Bor. 154428 and SS Cygni 213843 will soon be in the morning sky, and it is important that they should be watched at every opportunity. The following observers deserve commendation for the number and distribution of their observations: Messrs. Bouton, Chandra, Peltier and Pickering.

A special meeting of the Council was held in New York City on December 21, at which resolutions of sympathy were passed on the deaths of Messrs. Gray, Berger, and Burbeck. Mr. M. J. Jordan, 30 State St., Boston, Mass., was elected Treasurer to succeed Mr. Burbeck, to hold office until the next annual election or until his successor has been elected. Bills due for 1921 will be issued soon,

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1920.

November 0 = J. D. 2422629 December 0 = 2422659

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
001046	X Androm.	2661.6	9.3	Hu.	2661.7	10.0	Pi.	2667.6	9.2	M.			
001620	T Ceti	2603.4	5.9	L.	2639.3	5.3	L.						
001726	T Androm.	2603.1	*11.0*	Ch.									
001755	T Cassiop.	2603.3	10.4	L.	2654.4	7.8	L.	2661.7	8.2	Pi.	2667.7	8.9	M.
001838	R Androm.	2603.1	*11.0*	Ch.	2621.4	10.8	Ch.	2642.4	9.0	Pe.	2647.5	9.2	Ro.
		2648.5	9.1	Ro.	2649.5	9.0	Ro.	2650.5	8.9	Ro.	2652.5	9.0	Ro.
		2654.5	8.5	Ro.	2660.5	8.5	Ro.	2661.5	8.4	Ro.	2661.6	8.5	Hu.
		2661.7	9.0	Pi.	2664.5	8.6	Ro.	2667.6	8.6	Pt.	2667.7	8.9	M.
		2669.5	8.6	Ro.	2673.5	8.7	Ro.	2674.5	8.6	Ro.	2675.5	8.5	Ro.
001909	S Ceti	2602.2	*11.5*	Ch.									
004047	U Cassiop.	2661.7	*12.4*	Pi.	2667.6	*12.2*	M.	2670.6	12.5	Y.			
004435	V Androm.	2647.6	9.7	B.	2661.6	10.0	Hu.	2661.7	10.0	Pi.			
004958	W Cassiop.	2647.5	8.7	B.	2658.5	9.0	K.	2660.5	9.0	Gd.	2661.6	8.7	Hu.
		2661.7	8.9	Pi.	2667.7	8.5	Pt.						
010940	U Androm.	2661.7	*12.6*	Pi.									
011208	S Piscium	2670.6	*13.6*	Y.									
011272	S Cassiop.	2677.5	*11.5*	Pi.									
011712	U Piscium	2666.6	12.3	Pi.									
012350	RZ Persei	2661.7	*12.1*	Pi.	2670.6	*13.0*	Y.						
012502	R Piscium	2657.5	11.6	Sz.	2661.6	11.4	Sz.	2667.5	12.5	Y.			
013238	RU Androm.	2603.1	*11.0*	Ch.	2647.6	10.7	B.	2661.7	10.1	Pi.	2667.7	10.4	Pt.
013338	Y Androm.	2603.1	*11.0*	Ch.	2661.7	*12.4*	Pi.						
014958	X Cassiop.	2647.5	10.6	B.	2661.7	11.8	Pi.	2667.5	11.3	Y.	2667.7	12.1	Pt.
015354	U Persei	2647.5	10.5	B.	2661.6	10.5	Hu.	2667.5	10.7	Pi.	2667.7	10.5	Pt.
021024	R Arietis	2611.4	8.8	L.	2639.3	8.6	L.	2647.5	9.0	B.	2661.5	10.2	Pt.
		2661.5	9.8	O.	2666.6	10.4	Pi.	2670.5	10.5	O.			
021143a	W Androm.	2647.6	10.4	B.	2667.5	11.2	Pi.						
021403	o Ceti	2601.1	6.8	Ch.	2611.2	7.0	Ch.	2611.7	6.9	L.	2619.5	7.4	Ch.
		2625.1	7.8	Ch.	2638.4	7.5	L.	2642.3	8.5	Pe.	2649.7	8.4	Sz.
		2654.4	8.5	L.	2657.5	8.6	Sz.	2661.5	9.0	Pt.	2661.5	8.7	O.
		2661.6	8.8	Sz.	2666.5	8.8	O.	2667.6	8.8	Sz.	2667.6	9.0	Ya.
		2671.6	8.0	Hu.	2671.6	8.8	O.	2673.5	9.0	Sz.			
021558	S Persei	2647.6	10.3	B.	2667.5	10.7	Pi.						
022150	RR Persei	2667.5	12.4	Y.									
022813	U Ceti	2602.2	9.9	Ch.	2621.1	8.7	Ch.	2667.6	7.6	Pt.	2670.6	7.8	Y.
023133	R Trianguli	2647.6	10.2	B.	2666.6	11.0	Pi.	2667.7	10.9	Pt.	2671.5	11.3	M.
		2677.6	11.1	Ya.									
024356	W Persei	2647.6	9.3	B.	2658.5	9.4	Cl.	2659.5	9.2	Gd.	2661.5	9.6	Pt.
		2661.6	9.2	Hu.	2667.5	9.4	Pi.	2671.5	9.7	M.			
030514	U Arietis	2670.6	*13.5*	Y.									
031401	X Ceti	2611.7	10.0	L.	2639.3	11.7	L.	2667.6	11.7	Pt.			
032043	Y Persei	2647.6	10.0	B.	2661.6	9.3	Hu.	2667.5	9.9	Pt.			
032335	R Persei	2661.5	8.9	Pt.									
032443	Nova Persei 2	2667.7	12.6	Pt.									
042209	R Tauri	2647.6	8.7	B.	2667.6	10.0	M.	2667.6	10.0	Pt.	2671.6	9.9	Hu.
042215	W Tauri	2652.6	*12.4*	B.	2661.6	12.6	Sz.	2666.6	12.5	Pi.	2667.6	12.4	Pt.
		2667.6	12.0	M.									
042309	S Tauri	2667.6	*12.0*	M.	2671.6	10.3	Hu.						
043065	T Camelop.	2611.4	12.0	L.	2677.6	*12.2*	Pi.						
043208	RX Tauri	2660.6	13.0	B.	2665.7	12.9	E.						

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
043274	X Camelop.	2647.6	7.7	B,	2661.5	8.3	O,	2666.5	8.5	O,	2667.5	8.2	Y,
		2667.8	8.0	Pt,	2670.5	8.5	O,	2671.6	8.7	O,	2677.6	8.7	Pi.
045307	R Orionis	2670.6	12.0	Y.									
045514	R Leporis	2611.7	9.4	L,	2612.3	9.8	Ch,	2654.4	9.5	L,	2661.6	9.8	Sz,
		2667.6	9.0	Pt,	2667.7	9.6	M,	2673.7	8.4	B.			
050003	V Orionis	2670.6	*13.0*	Y.									
050022	T Leporis	2667.7	10.5	M,	2667.7	10.4	Pt.						
050953	R Aurigae	2660.6	13.2	B.									
052034	S Aurigae	2613.4	10.3	L,	2639.4	10.3	Pe,	2640.4	10.1	L,	2642.4	10.3	Pe,
		2649.7	10.0	L,	2658.5	10.0	Cl,	2666.7	10.0	Pi,	2673.6	8.9	B.
052404	S Orionis	2665.7	13.6	E.									
*053005*a	T Orionis	2611.7	11.5	L.	2612.6	11.5	L.	2638.4	11.3	L.	2648.2	9.8	L.
		2665.7	9.8	E,	2667.7	9.9	Pt,	2667.7	10.0	M,	2671.6	9.7	Hu.
		2673.7	9.6	B,	2677.7	10.0	Pi.						
053036	W Aurigae	2613.4	9.2	L,	2649.7	9.9	L,	2667.6	10.9	Pi,	2667.7	10.7	Pt.
053068	S Camelop.	2667.8	8.5	Pt,	2677.6	8.7	Pi.						
053326	RR Tauri	2667.5	11.2	Cl,	2673.6	12.0	B.						
053531	U Aurigae	2667.7	13.0	Pt,	2670.6	*13.0*	Y.						
054319	SU Tauri	2611.3	10.0	Ch,	2611.7	9.6	L,	2638.5	9.2	L,	2646.6	9.5	B,
		2652.6	9.5	B,	2653.4	9.4	L,	2658.5	9.1	Cl,	2660.6	9.5	B,
		2661.6	9.5	Pt,	2665.5	9.5	O,	2667.5	9.3	Cl,	2667.5	9.4	Pi,
		2667.7	9.4	Pt,	2670.6	9.5	Y,	2671.5	9.0	Cl,	2671.6	9.3	Hu,
		2673.5	9.3	Pt,	2673.6	9.5	B.						
054615a	Z Tauri	2670.6	10.8	Y.									
054615b	RS Tauri	2670.6	9.2	Y.									
054615c	RU Tauri	2670.6	12.7	Y.									
054920	U Orionis	2611.3	8.6	Ch.	2649.6	8.9	Sz,	2661.6	9.0	Sz,	2661.6	9.5	Pt.
		2666.5	9.5	O,	2667.5	9.7	Pi,	2667.6	9.0	Sz,	2671.6	9.0	Hu,
		2673.5	9.1	Sz,	2673.6	9.2	B.						
054974	V Camelop.	2660.6	10.2	B,	2667.5	*13.0*	Y,	2677.6	*12.2*	Pi.			
055353	Z Aurigae	2667.6	11.0	Pi.									
060450	X Aurigae	2660.6	10.2	Ro,	2661.6	10.0	Ro,	2664.6	10.2	Ro,	2667.6	9.8	Pi,
		2667.7	10.0	Pt,	2669.6	10.0	Ro,	2673.6	10.2	Ro,	2673.6	9.7	B,
		2674.6	10.2	Ro,	2675.6	10.4	Ro,	2677.5	10.3	Pi.			
060547	SS Aurigae	2611.2	11.2	Ch,	2611.4	11.0	L,	2612.2	11.2	Ch,	2613.2	11.4	Ch,
		2613.4	11.6	L,	2615.2	*11.6*	Ch,	2638.4	*12.4*	L,	2639.3	*12.4*	L,
		2639.4	*12.6*	Pe,	2640.4	*13.8*	L,	2649.7	*13.5*	L,	2654.4	*11.0*	L,
		2657.5	*12.4*	Pt,	2658.5	*12.4*	Cl,	2658.5	*13.0*	Y,	2658.5	*11.6*	K,
		2659.7	*12.4*	L,	2661.5	*10.8*	O,	2661.6	*12.6*	Pt,	2662.5	*12.4*	Pt.
		2666.5	10.8	O,	2667.5	10.7	Pt,	2667.5	10.7	Cl,	2667.6	10.8	Pi,
		2667.6	11.0	K,	2667.7	10.8	M,	2670.5	11.0	Pi,	2670.5	10.8	O,
		2670.6	10.6	Y,	2670.9	11.0	Pt,	2671.5	11.2	Cl,	2671.6	10.8	O,
		2673.5	11.8	Pt,	2673.7	11.6	Pi,	2674.5	11.9	Cl,	2674.6	11.8	K,
		2677.5	*11.4*	Pi.									
061647	V Aurigae	2667.6	10.6	Pi,	2673.6	9.7	B.						
061702	V Monoc.	2677.7	*11.1*	Pi.									
063159	U Lyncis	2667.5	*13.0*	Y.									
063308	R Monoc.	2677.7	*11.2*	Pi.									
063558	S Lyncis	2667.6	9.3	Pi,	2667.7	9.3	M,	2667.7	9.6	Pt,	2670.5	9.2	O,
		2673.6	9.2	B.									
064030	X Gemin.	2667.7	8.8	M,	2677.6	9.3	Pi.						
064707	W Monoc.	2667.7	10.8	Pt,	2677.7	11.3	Pi.						
065111	Y Monoc.	2670.6	10.2	Y,	2677.6	10.3	Pi.						

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
065355	R Lyncis	2667.5	*13.1*	Y,	2673.7	*11.9*	Pi.						
070109	V Can. Min.	2677.7	11.4	Pi.									
070122a	R Gemin.	2614.4	7.2	Ch,	2642.4	7.5	Pe,	2659.4	7.8	Pe,	2667.7	8.0	Pt.
070122b	Z Gemin.	2667.7	12.3	Pt.									
070122c	TW Gemin.	2642.4	8.4	Pe,	2659.4	8.1	Pe.						
070310	R Canis Min.	2677.6	9.1	Pi.									
071044	L_2 Puppis	2614.4	5.1	Ch.									
071713	V Gemin.	2667.7	8.0	Pt,	2677.6	8.7	Pi.						
072708	S Can. Min.	2614.4	9.5	Ch,	2660.6	12.4	Ro,	2661.6	*10.0*	Sz,	2661.6	12.4	Ro,
		2664.6	12.4	Ro,	2667.7	11.6	M,	2673.6	12.5	Ro,	2677.7	*11.3*	Pi,
072811	T Can. Min.	2677.6	*11.4*	Pi.									
073508	U Can. Min.	2667.7	10.6	Pt,	2667.7	10.6	M,	2670.6	10.7	Y,	2677.6	10.5	Pi.
074922	U Gemin.	2611.7	12.5	L,	2612.6	13.0	L,	2614.4	*11.7*	Ch,	2638.4	*11.7*	L,
		2648.7	*13.3*	L,	2649.7	*13.7*	L,	2666.5	*10.9*	O,	2667.6	*12.4*	Pt,
		2667.7	*12.4*	M,	2670.6	*13.3*	Y,	2670.9	*13.3*	Pt,	2671.6	*10.5*	O,
		2673.6	*13.3*	Pt,	2673.7	*13.9*	B,	2673.7	*12.4*	Pi,	2677.6	*11.7*	Pi.
081112	R Cancri	2615.4	11.3	Ch,	2667.7	10.5	Pt,	2673.7	10.4	Pi.			
081617	V Cancri	2673.7	12.0	Pi.									
083019	U Cancri	2673.7	11.1	Pi.									
083350	X Urs. Maj.	2673.7	*11.5*	Pi.									
084803	S Hydrae	2615.4	8.2	Ch,	2667.7	8.0	M,	2667.8	8.0	Pt.			
085008	T Hydrae	2615.4	8.1	Ch,	2667.8	10.2	Pt.						
085120	T Cancri	2611.7	8.8	L,	2667.8	8.5	Pt,	2673.7	9.0	Pi.			
090151	V Urs. Maj.	2667.6	10.4	K.									
090425	W Cancri	2673.7	9.4	Pi.									
093014	X Hydræ	2667 8	10.8	Pt.									
093178	Y Draconis	2667.6	10.0	Y.									
093934	R Leo. Min.	2614.4	*10.5*	Ch,	2673.7	11.8	Pi.						
094211	R Leonis	2617.5	9.1	Ch,	2667.8	6.5	Pt.						
103769	R Urs. Maj.	2617.4	11.4	Ch,	2667.7	7.7	M,	2667.8	7.4	Pt.			
104620	V Hydrae	2621.5	7.3	Ch.									
104814	W Leonis	2667.9	12.4	Pt.									
122532	T Can. Ven.	2667.8	11.1	Pt.									
123160	T Urs. Maj.	2617.4	10.5	Ch,	2658.5	*10.8*	K.						
123307	R Virginis	2667.9	9.0	Pt.									
123459	RS Urs. Maj.	2617.4	*11.0*	Ch,	2658.5	8.8	K,	2667.8	8.9	Pt.			
123961	S Urs. Maj.	2603.3	9.7	L,	2617.4	8.6	Ch,	2638.3	7.9	L,	2658.5	7.5	K,
		2667.7	8.3	M,	2667.8	8.0	Pt.						
124606	U Virginis	2667.9	9.0	Pt.									
134440	R Can. Ven.	2667.8	11.6	Pt.									
141567	U Urs. Min.	2601.1	10.9	Ch.									
141954	S Bootis	2600.1	*11.0*	Ch,	2603.3	*12.5*	L,	2667.8	9.5	Pt.			
142539	V Bootis	2603.3	7.5	L,	2639.2	7.3	L,	2667.8	8.2	Pt.			
142584	R Camelop.	2661.5	8.4	O,	2670.5	8.5	O.						
143227	R Bootis	2601.0	8.2	Ch,	2667.9	10.0	Pt.						
151714	S Serpentis	2611.3	10.1	L.									
151731	S Cor. Bor.	2615.0	*11.0*	Ch,	2667.9	7.8	Pt.						
153378	S Urs. Min.	2647.5	8.6	Ro,	2648.5	8.5	Ro,	2649.5	8.4	Ro,	2650.5	8.6	Ro,
		2652.5	8.7	Ro,	2654.5	8.6	Ro,	2660.5	8.8	Ro,	2661.5	8.9	Ro,

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
153378	S Urs. Min.	2662.5	9.3	Pt,	2664.5	9.0	Ro,	2666.5	9.2	Jd,	2667.6	9.5	K,
		2669.5	9.0	Ro,	2673.5	9.3	Ro,	2674.5	9.4	Ro,	2675.5	9.4	Ro.
154428	R Cor. Bor.	2600.1	6.1	Ch,	2613.3	6.0	L,	2604.1	6.0	Ch,	2611.3	6.0	L,
		2615.1	6.0	Ch,	2638.3	6.3	L,	2639.2	6.1	L,	2642.6	6.3	Mu,
		2667.9	6.1	Pt,	2670.9	6.1	Pt.						
155018	RR Librae	2604.0	*11.0*	Ch.									
162119	U Herculis	2604.1	11.0	Ch.									
163137	W Herculis	2601.1	9.0	Ch,	2610.1	8.4	Ch,	2615.1	8.4	Ch,	2619.0	8.4	Ch,
		2655.5	9.2	Y.									
163266	R Draconis	2601.1	*11.0*	Ch,	2655.5	8.4	Y,	2662.5	8.3	Pt.			
165631	RV Herculis	2657.5	13.6	M.									
170215	R Ophiuchi	2601.1	*11.0*	Ch.									
175458a	T Draconis	2658.5	12.3	Y.									
175458b	UY Draconis	2658.5	11.0	Y.									
175519	RY Herculis	2604.1	11.4	Ch,	2615.1	10.4	Ch,	2625.1	9.6	Ch.			
180531	T Herculis	2604.1	11.2	Ch,	2611.3	12.4	L,	2638.3	12.4	L,	2662.5	9.6	Pt,
		2667.5	9.0	M.									
180565	W Draconis	2667.8	10.7	Pt.									
180911	Nova Ophiu.4	2603.3	10.0	L,	2639.2	11.0	L.						
181031	TV Herculis	2639.3	*12.0*	L.									
181136	W Lyræ	2603.3	11.3	L,	2639.3	9.1	L,	2646.5	8.3	B,	2658.5	7.8	Y,
		2661.5	7.6	Pt,	2666.5	7.8	Pi.						
183149	SV Draconis	2658.5	*13.0*	Y.									
183225	RZ Herculis	2658.5	*12.2*	Y.									
183308	X Ophiuchi	2611.3	9.0	L,	2639.2	8.9	L.						
184205	R Scuti	2600.1	5.7	Ch,	2603.3	5.6	L,	2611.3	5.4	L,	2619.1	5.2	Ch,
		2623.1	5.0	Ch,	2623.2	5.0	L,	2638.3	5.4	L,	2642.6	5.6	Mu,
		2648.3	5.6	L,	2654.3	5.7	L,	2657.6	5.7	Mu,	2658.5	5.8	K,
		2661.5	5.9	Sz,	2661.5	5.7	Pt,	2661.6	6.0	Mu,	2671.6	6.2	Mu,
		2673.5	6.4	Sz.									
184300	Nova Aquil.3	2600.1	8.5	Ch,	2621.1	8.7	Ch,	2639.2	8.5	L.	2658.5	8.6	K,
		2661.5	8.6	Pt.									
185032	RX Lyrae	2657.5	*15.0*	M.									
190108	R Aquilae	2646.5	6.5	B.									
190529a	V Lyrae	2658.5	*13.3*	Y.									
191033	RY Sagittarii	2603.3	6.4	L.									
191350	TZ Cygni	2658.5	11.4	Y.									
191637	U Lyrae	2661.5	11.7	Pt,	2666.5	11.5	Pi,	2667.5	11.5	M.			
192928	TY Cygni	2667.5	10.1	Pt,	2667.5	10.3	M.						
193449	R Cygni	2611.2	*12.0*	Ch,	2639.3	12.1	Pe,	2657.5	10.5	M,	2661.5	10.1	Pt,
		2661.5	9.9	Sz,	2670.5	9.8	O,	2673.5	9.9	Sz.			
193732	TT Cygni	2660.6	7.5	Hu,	2660.6	7.8	B.						
194048	RT Cygni	2611.2	*11.5*	Ch,	2657.5	10.6	M,	2660.6	9.0	Hu,	2661.5	9.1	Pt,
		2661.6	9.3	Sz,	2666.5	9.0	Pi,	2667.5	8.9	Ya,	2670.5	8.6	O,
		2673.5	9.0	Sz.									
194348	TU Cygni	2657.5	12.2	M,	2661.5	12.2	Pt,	2666.5	*12.1*	Pi.			
194632	χ Cygni	2611.2	9.3	Ch,	2639.3	10.6	Pe,	2652.5	10.8	B,	2658.5	*10.2*	K,
		2661.5	11.8	Pt,	2661.6	11.6	Ya,	2665.5	11.7	B,	2667.5	11.4	M.
195116	S Sagittae	2642.6	6.3	Mu,	2657.6	6.0	Mu,	2661.6	5.4	Mu,	2671.6	5.3	Mu,
		2673.6	5.6	Mu.									
195553	Nova Cygni 3	2602.4	7.7	L,	2603.4	7.7	L,	2611.3	8.3	L,	2613.4	8.5	L,
		2626.4	8.7	L,	2638.4	8.9	L,	2640.3	8.7	L,	2647.3	8.5	L,

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
195553	Nova Cygni 3	2647.5	8.9	Ro,	2648.5	8.9	Ro,	2649.5	8.8	Ro,	2650.5	8.9	Ro,
		2652.5	8.9	Ro,	2652.5	9.4	B,	2653.3	8.8	L,	2654.5	8.8	Ro,
		2657.5	8.9	Ro,	2657.5	8.6	Pt,	2658.5	9.3	Y,	2658.5	9.2	Gd,
		2658.5	8.7	K,	2660.5	8.8	Ro,	2661.5	8.7	Ro,	2661.5	8.6	Pt,
		2661.5	8.6	O,	2661.6	9.1	Ya,	2661.6	9.2	Hu,	2662.5	8.8	Pt,
		2663.6	8.6	Ka,	2664.5	8.6	Ro,	2665.5	9.2	B,	2666.5	9.4	Pi,
		2667.5	8.6	Pt,	2667.5	9.2	Cl.	2667.6	8.7	K,	2669.5	8.6	Ro.
		2674.5	8.6	Ro,	2674.6	9.0	Hu,	2675.5	8.5	Ro.			
195849	Z Cygni	2657.5	11.1	M,	2661.5	9.5	Pt,	2666.5	9.6	Pi.			
200647	SV Cygni	2660.6	8.3	B,	2661.6	8.0	Hu.						
200715a	S Aquilae	2651.5	10.6	B,	2661.5	11.8	Pt,	2666.6	11.5	Pi,	2671.5	9.1	Cl,
		2673.5	11.2	Sz,	2677.5	11.1	Ya.						
200715b	RW Aquilae	2651.5	9.1	B,	2666.6	9.2	Pi,	2671.5	8.5	Cl,	2673.5	8.9	Sz,
		2677.5	9.3	Ya.									
200812	RU Aquilae	2651.5	8.9	B.									
200906	Z Aquilae	2660.5	11.0	B.									
200916	R Sagittae	2671.5	8.9	Cl,	2673.5	8.8	Sz,	2677.5	9.1	Ya.			
200938	RS Cygni	2611.4	7.3	L,	2612.2	7.2	Ch,	2615.2	7.0	Ch,	2639.3	7.0	L,
		2662.5	7.3	Pt,	2667.5	8.4	M,	2667.5	8.4	Ya.			
201008	R Delphini	2603.3	11.5	L,	2639.2	9.6	L,	2646.6	9.1	B,	2667.5	8.6	Pt.
201121	RT Capricor.	2603.3	7.1	L,	2639.2	7.3	L.						
201130	SX Cygni	2657.5	13.7	M,	2658.5	*12.9*	Y.						
201437	P Cygni	2612.2	5.0	Ch.									
201647	U Cygni	2639.3	9.8	Pe,	2647.5	7.8	Ro,	2648.5	7.8	Ro,	2649.5	7.9	Ro,
		2649.6	7.8	Sz,	2650.5	7.8	Ro,	2652.5	7.8	Ro,	2654.5	7.8	Ro,
		2657.5	7.8	Ro,	2660.5	7.8	Ro,	2660.6	7.8	Gd,	2661.5	7.8	Sz,
		2661.5	7.8	Pt,	2661.5	7.8	Ro,	2664.5	7.7	Ro,	2666.5	9.0	Pi,
		2667.5	8.1	M,	2669.5	7.6	Ro,	2671.5	8.2	Ya.	2673.5	7.7	Sz,
		2673.5	7.5	Ro,	2674.5	7.4	Ro,	2675.5	7.5	Ro.	2676.6	7.6	Jd.
202539	RW Cygni	2667.6	9.0	M,	2671.5	8.9	Ya.						
202817	Z Delphini	2647.6	12.3	B,	2666.6	*11.7*	Pi.						
202946	SZ Cygni	2660.6	9.8	B,	2667.6	8.9	M,	2671.5	9.5	Ya.			
202954	ST Cygni	2657.5	13.5	M,	2658.5	13.3	Y,	2666.5	*12.1*	Pi.			
203226	V Vulpec.	2661.5	8.6	Pt.									
203611	Y Delphini	2646.6	11.9	B,	2666.6	*11.4*	Pi.						
203816	S Delphini	2646.6	9.9	B,	2657.5	11.0	M,	2658.5	10.2	Cl.			
203847	V Cygni	2613.2	11.6	Ch,	2652.6	10.0	B,	2666.5	9.8	Pi,	2667.5	12.2	M.
204016	T Delphini	2657.5	13.0	M.									
204104	W Aquarii	2611.4	*12.4*	L,	2648.3	*11.3*	L.						
204405	T Aquarii	2601.1	8.9	Ch,	2651.5	12.3	B,	2652.5	12.0	Ro,	2661.5	12.0	Ro,
		2664.5	12.0	Ro.									
204846	RZ Cygni	2657.5	12.0	M,	2658.5	*11.1*	Pi.						
205017	X Delphini	2671.5	12.2	Cl.									
205923	R Vulpec.	2660.5	10.2	B,	2661.5	10.6	Pt,	2666.6	11.2	Pi.			
210129	TW Cygni	2667.5	12.0	Y.									
210504	RS Aquarii	2611.3	10.4	L,	2648.3	*13.1*	L.						
210868	T Cephei	2603.3	10.3	L,	2613.2	9.9	L,	2639.3	9.1	L,	2661.6	7.7	Hu,
		2667.5	8.0	Pt,	2667.6	8.2	M,	2677.6	8.2	Ya.			
211614	X Pegasi	2666.6	*10.9*	Pi,	2667.5	12.2	Y.						
213244	W Cygni	2603.2	5.7	L,	2611.6	5.7	L.	2626.4	5.7	L.	2638.4	6.1	L,
		2661.5	6.8	O.									
213678	S Cephei	2665.5	10.7	B.									

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213753	RU Cygni	2667.6	8.9	Ya.									
213843	SS Cygni	2603.2	11.7	L,	2609.1	12.0	Ch,	2611.6	12.0	L,	2613.4	12.1	L,
		2619.1	11.5	Ch,	2626.4	*11.3*	L,	2628.3	11.9	L,	2638.4	12.0	L,
		2639.3	12.0	L,	2639.3	11.7	Pe,	2640.4	11.8	L,	2646.6	8.9	B,
		2647.3	8.6	L,	2647.5	9.3	Ro,	2647.6	9.1	B,	2648.3	9.6	L,
		2648.5	9.5	Ro,	2649.5	9.8	B,	2649.5	9.7	Ro,	2650.5	10.5	Ro,
		2652.5	11.2	B,	2652.5	11.2	Ro,	2653.3	12.0	L,	2654.5	11.5	Ro,
		2657.5	11.5	Pt,	2657.5	11.5	Ro,	2658.5	11.8	Pi,	2658.5	11.9	Cl,
		2658.5	11.7	Y,	2658.5	*11.8*	K,	26660.5	11.8	Ro,	2660.5	12.0	Gd.
		2660.5	11.8	B,	2661.5	12.0	Ro,	2661.5	11.7	Pt,	2661.6	11.8	Ya,
		2661.6	11.3	Hu,	2661.7	11.8	Pi,	2662.5	11.7	Pt,	2665.5	11.9	B,
		2666.5	11.8	Pi,	2666.5	11.9	Jd,	2667.5	11.6	Y,	2667.5	11.7	Cl,
		2667.5	12.0	Pt,	2667.5	*11.8*	K,	2667.5	12.2	M,	2668.5	12.0	B,
		2669.5	12.0	Ro,	2670.5	11.5	Y,	2670.5	11.7	Pi,	2671.5	11.4	Cl,
		2671.6	11.5	Hu,	2672.6	11.9	Jd,	2673.5	12.0	Ro,	2673.5	11.9	B,
		2673.5	11.5	Pt,	2674.5	12.0	Ro,	2675.5	12.0	Ro,	2676.5	12.0	Jd.
		2677.5	*11.3*	Ya.									
213937	RV Cygni	2660.6	7.7	B,	2661.6	7.3	Hu,	2667.6	8.1	Ya.			
215934	RT Pegasi	2658.5	*12.0*	Y.									
220412	T Pegasi	2640.4	*13.2*	L.									
222129	RV Pegasi	2647.6	12.7	B.									
222439	S Lacertae	2611.3	12.8	L,	2640.4	10.8	L,	2661.7	9.8	Pi,	2673.5	8.5	B.
223841	R Lacertae	2611.3	10.8	L,	2640.4	10.3	L.						
225120	S Aquarii	2653.6	*12.5*	B,	2658.5	*12.8*	Y.						
225914	RW Pegasi	2658.5	12.5	Y.									
230110	R Pegasi	2660.5	12.0	Ro,	2661.5	11.5	Ro,	2664.5	11.2	Ro,			
		2669.5	11.0	Ro,	2673.5	10.9	Ro.						
230759	V Cassiop	2642.4	8.4	Pe,	2647.5	83	Ro,	2648.5	8.2	Ro,	2649.5	8.3	Ro.
		2650.5	8.2	Ro,	2652.5	8.1	Ro,	2654.5	8.2	Ro,	2657.5	8.3	Ro,
		2660.5	8.7	Ro,	2661.5	8.8	Ro,	2661.6	8.3	Hu,	2661.7	9.2	Pi,
		2664.5	9.3	Ro,	2667.5	9.6	Pt,	2669.5	9.6	Ro,	2673.5	10.0	Ro,
		2674.5	10.2	Ro,	2675.5	10.3	Ro,	2676.5	10.1	Ao,	2676.5	10.1	Jd.
231425	W Pegasi	2603.3	12.7	L,	2613.4	12.0	L,	2640.4	11.1	L,	2648.3	10.9	L.
231508	S Pegasi	2647.6	8.8	B,	2661.6	9.7	Hu,	2667.5	10.1	Pt.			
233335	ST Androm.	2603.1	*10.9*	Ch,	2625.1	10.9	Ch,	2661.6	9.3	Hu,	2661.7	10.7	Pi,
		2667.5	10.4	Pt.									
233815	R Aquarii	2600.1	10.2	Ch,	2621.1	9.2	Ch,	2667.5	6.5	Pt.			
233956	Z Cassiop.	2647.5	12.9	B,	2661.7	*12.1*	Pi.						
235209	V Ceti	2673.6	10.1	Pt.									
235350	R Cassiop.	2652.5	9.8	B,	2661.7	11.2	Pi.						
235525	Z Pegasi	2667.5	12.6	Pt.									
235855	Y Cassiop.	2647.5	10.4	B.									
235939	SV Androm.	2661.7	10.0	Pi,	2667.6	10.1	Pt,	2670.6	10.3	Y,	2673.6	9.5	B.

Total observations: 805 Stars Observed: 199. Observers: 21.

and it is hoped that remittances will be promptly made, and thus assure the Association of the sinews of war for the coming year. The following have been elected to active membership:

Mr. F. H. Chandler, Belgrade Lakes, Me.
Mr. A. Gaulocker, Yonkers, N. Y.
Mr. A. J. Starr, Springfield, Ohio.
Dr. W. C. Stevens, Detroit, Mich.

A second edition of the catalogue of the slides in the Association collection

will be sent to all members shortly, together with the reprint of monthly reports for the past year. Those failing to receive their copies should notify Mr. Campbell. The distribution of charts is in the hands of Mr. A. C. Perry, 226 Halsey St., Brooklyn, N. Y., and those desiring additional supplies should consult him.

Mr. S. C. Hunter has been appointed by the President as the representative of the Association to carry our greetings and the offer of our co-operation to the newly organized Variable Star Association at Lyons, France. He is planning to be in Europe for some time. Our Secretary, Mr. Olcott, leaves shortly for an extended trip through the South.

About twenty members and friends of the A. A. V. S. O. gathered at the Dearborn Observatory on December 27, for a most delightful meeting. The program included an inspection of the Observatory and its working program, a session for papers on the work of the Association and allied topics, an exhibition of some of the slide collection, and a very lovely dinner at the Delta Upsilon Fraternity House, as the guests of Northwestern University and Dearborn Observatory. Professor Fox, the Director of the Observatory was a most courteous host, and the warmest thanks of the Association were extended to him. All present voted the meeting a great success, and were delighted with the opportunity of meeting so many kindred spirits.

The following members contributed to this report: Messrs. Ayulo "Ao," Bouton "B," Chandra "Ch," Clement "Cl," Eaton "E," Godfrey "Gd," Hunter "Hu," Jordan "Jd," Kaster "Ka," Kimball "K," Lacchini "L," McAteer "M," Mundt "Mu," Olcott "O," Peltier "Pt," de Perrot "Pe," Pickering "Pi," Rhorer "Ro," Schwartz "Sz," Yalden "Ya," and Miss Young "Y."

HOWARD O. EATON, Recording Secretary.

GENERAL NOTES.

Notice Concerning the Wolf-Palisa Photographic Charts of the Heavens. —A continuation of the issue of these charts will doubtless be desired by many observers. Dr. Palisa also intends to continue this work which he has begun, if he is able to obtain the necessary means for this purpose. It would seem that the funds could be secured if a sale could be found for the remaining copies of the nine series already published, containing 20 prints each, or a total of 180 prints. It is proposed that these should be sold at the price set in 1909, or at the former peace-time price. At that time the price of a series of 20 prints was set at $10 for purchases made four months after the appearance of each series. It is requested that those observatories, institutions and friends of astronomy who have not yet obtained these nine series should address themselves directly to Dr. Johann Palisa, Universitäts Sternwarte, Türkenschanzstrasse 17, Wien XVIII, Austria.

To those unfamiliar with these very useful charts, some further remarks of explanation may be desirable.

The photographs were made by Professor Max Wolf of Heidelberg with the 16-inch Bruce photographic doublet. The size of the bromide of silver print is 11 inches (28 cm) in height, and 8⅝ inches (22 cm) in width. The scale, at the equator, is $1'/_{10}$ inches (37 mm) to the degree. The coördinates

are ruled for each degree and printed on the margin, referred to the equinox of 1875.0. The reduction to 1855.0 the date of the Bonn *Durchmusterung*, is given for each chart. The publication was prepared by Dr. J. Palisa and Dr. J. Rheden of the Vienna Observatory. The exposures by Dr. Wolf were generally long enough so that stars to about the 16th magnitude are shown on the chart. A printed list was issued, giving the limits in right ascension and declination of each chart, with the date on which the original plate was taken. Only 31 charts are entirely south of the celestial equator.

It is to be hoped that there will be a sufficient response to this notice of Dr. Palisa, in the way of orders for the first nine series at $90 for the whole set, so that the publication of the tenth and later series may be begun. Perhaps it should be added that these charts are so prepared that they are just as valuable for direct visual comparison with the sky by an observer at the telescope as for comparison with negatives of the same region. The size, stated above, makes them very convenient for use at the telescope.

Two Nebulae with Unparalleled Velocities.—Recent observations here with the nebular spectrograph have shown that the nebulæ N. G. C. 584 and N. G. C. 936, both evidently of the spiral family, possess much the highest velocities yet observed for any objects.

A plate exposed to N. G. C. 584, (R.A. = $1^h\,27^m.3$. Dec. = $-7°\,16'$), on the useful parts of the clear nights from December 31 to January 14, total exposure about 28 hours, gave a serviceable, although somewhat weak, spectrogram. The spectrum, approximately of the solar type, shows its lines enormously displaced toward the longer wave lengths, corresponding to the exceptional velocity of 1800 kilometers per second. The motion is away from the Sun.

Nebula N. G. C. 936, (R.A. = $2^h\,23^m.$, Dec. = $-1°\,33'$), was recently photographed for its spectrum with an exposure of about 34 hours. The resulting spectrogram, having a spectrum similar to that of the sun, exhibits also a very large displacement of the nebular lines. The provisional result from the plate is that the nebula is receding from the Sun with a velocity of fully 1300 kilometers per second.

Brief descriptions of these objects by Mr. Lampland from his direct photographs of them made with the 40-inch reflector are as follows:

> "The nebula N.G.C. 584 is of the type having a brilliant nucleus, and apparently with but little detail in the surrounding nebulous matter. In our photograph not much of the fainter outlying nebulosity is shown. Elongation is apparently in P. A. about 60°. The nucleus is catalogued in the Bonn Durchmusterung as star —7°.248, magnitude 9.7.
>
> The photograph of the nebula N.G.C. 936 shows it to be an interesting object. The most conspicuous structure is the rather large and brilliant nucleus with extensions on diametrically opposite sides, resembling somewhat the view of the ball of Saturn and the ansæ of the rings when the rings are presented at less than half their maximum opening. This brilliant part of the image is placed centrally in an oval-shaped disk of nebulosity rather faint and showing but little structure. The bright Saturn-like part is approximately 85″ in length in P. A. 80°. The elliptic disk of faint nebulosity has dimensions about $2'.5 \times 3'.5$ with the longer axis in P. A. about 160°. In photographs of short exposure the nucleus is small and rather well defined.
>
> Both of these nebulae should doubtless be classed with the spirals."

Lowell Observatory Observation Circular. V. M. SLIPHER.
Flagstaff, Arizona, January 17, 1921.